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Thermal Phenomena in Carbonizat

[From a paper by H. HOLLINGS and J. W. COBB, read before the Institution of Gas Engineers, England.

The first recognition of the importance attaching to the investigation of the thermal side of distillating seems to have been by Mahler, who in 1891 examined the products of distillation of Commentry coal. He determined the yield of each product (coke, tar and gas) and its calorific value. The results show that the calorific value of 100 kilos. of coal exceeds that of the products by 25,479 calories, or 3.5 per cent of the value of the coal. The generally accepted interpretation of this result is that this quantity of heat is evolved as a net result of the chemical actions taking place during distillation, and is, therefore, not available as potential energy in the products. One assumption must, however, be made before this can be taken as strictly correct. The calorific values are not determined at the distillation temperature, and hence the heat supplied to the coal in raising it to the distillation temperature, and that abstracted from the products during cooling, have to be considered.

More recently Constam, Kolke and Schläpfer determined the calorific value of coal and its products in a similar manner. The figures for 28 English and Continental coals have been given, and in each case the calorific value of the coal exceeds that of its products, ranging from 2.1 per cent. to 7.2 per cent. of the net calorific value of the coal (see Tables IV and V.). These authors quote Poole as having, in 1898, found the calorific value of an American coal to exceed that of its products by 3.06 per cent.

There have just been published figures by Frankenfeld showing the distribution of the heat units of coal among the products of carbonization in inclined retorts, and the figures are in very close agreement with Mahler's laboratory experiment. In all these cases, except that of Klason, it is assumed that the difference between the calorific values of coal and of its products is the same at ordinary temperatures as it is at the distillation temperature.

Euchene has attacked the problem in an entirely different manner; and since his figures are the result of very careful work, and are often quoted, we have examined them in some detail. Briefly, Euchene has drawn up a heat balance of a retort setting. Thus if

A is the heat furnished by the fuel in the grate.
x the heat absorbed during distillation.
C the heat carried away by the flue gases.
D the heat carried away by the volatile matter leaving the retort.
F the heat lost by radiation.
E the heat retained by the coke drawn from the retort.
H the heat carried away by ashes and clinker.

$$\text{Then } A = x + C + D + F + E + H$$
$$\text{or } x = A - (C + D + E + F + H)$$

In 1906 Barnum (Proceedings New England Association Gas Engineers, 1906, p. 58) determined the heat balance of a regenerative setting in a similar manner to Euchene. In the following table Euchene's and Barnum's results are summarized:

TABLE I.

	1.	2.	3.	4	5.
A Heat of fuel	151,816	143,683	135,550	100,304	119,791
C Flue loss	89,962	81,311	76,712	32,649	67,110
D Heat in volatile matter	16,680	17,999	20,017	17,999	12,963
E Heat in coke	25,573	24,585	23,087	24,585	18,727
H Heat in ashes	1,344	1,272	1,200	1,184	included in C
F Radiation loss.....	23,596	22,114	20,885	25,306	11,628
C + D × E + F + H....	153,155	147,281	141,901	101,723	110,428
x = A — (C + D + E + F + H).....	— 1.339	— 3,598	— 6,351	— 1,419	+ 9,9.363

Column 1 is Euchene's figures for coal No. 2 in ordinary setting.
" 2 " " " " No. 3 " "
" 3 " " " " No. 4 " "
" 4 " " " " No. 3 in regenerator setting.
" 5 is Barnum's figures converted from B.T.U. per 100 lbs. to K C.U. per 100 kilos.

It will be seen that the values of x found by Euchene agree in sign with those already quoted. Although Barnum's result is so different, not only in degree but in sign, this is often overlooked. Indeed Lewes ("The Carbonization of Coal," p. 124) quotes Barnum's results as confirming those of Euchene.

Probable Errors in Euchene's Method.—(Euchene found the value

1. Slightly abridged.—EDS.

of x to be — 3,598 K.C.U. per 100 kilos. of coal for coal No. 3, when distilled in a non-regenerative setting (Column 2 in Table 1) and — 1,419 K.C.U. when distilled in a regenerative setting (Column 4). This might be explained in part by the different conditions of distillation. It is well known that if the conditions of distillations — *eg.*, the rate of heating-up the coal and the temperature of the retort walls in the early stages of distillation—are altered, the products will be different. In this case the value of x (the heat absorbed in the change from coal to distillation products) will be altered. A study of Euchene's calculations shows that he has assumed the conditions of distillation and the products formed to be the same in both retort settings. A more probable explanation of the difference between the two results is that the figure is within the limits of experimental error. A large number of measurements and certain assumptions are necessary to determine the various heat losses from the setting. It will be seen from the table that the value of x is very small compared with the heat quantities involved in its deduction. It is interesting to note that Euchene admits a large error in the heat balance of the regenerative setting. In this case a separative balance was drawn up for the producer, furnace and regenerator, as the following summary shows:

TABLE II.—*Producer.*

A_1 heat of partial combustion of coke	43,212	Sensible heat of producer gas	22,434
Experimental error	1,418	A_2 decomposition of water vapor	15,318
		H loss in ashes	1,184
		F_1 radiation	5,694
	44,630		44,630

Regenerator.

Heat in gases leaving furnace	58,370	C flue loss	32,649
		F_2 radiation	2,386
		Heat in sec. air to furnace by difference	22,335
	57,370		57,370

Furnace.

Sensible heat in gas	22,434	Heat in gases to regenerator	57,370
" " air	22,335	D heat in volatile matter	17,999
A, heat of combustion	72,410	E heat in coke	24,585
		F_3 radiation	18.644
			118,598
		x —	1,419
	117,179		117,179

In the condensed summary of these three balances in column 4 of Table I, we have subtracted the error 1,419 from the radiation loss in order to avoid introducing a separate item. If, however, this error is in the determination of the sensible heat of the producer gas, it will be carried forward to the furnace balance sheet, and the value of x will become — 2,427, an increase of 100 per cent.

In Euchene's work the possibility of error mentioned in connection with Mahler's method is eliminated, since he is concerned with the heat quantities at the distillation temperature; but in view of the error to which the value found for x is subject, one should be very cautious in drawing conclusions from the results obtained.

TABLE I1I.

	Oxygen in Coal.	Volatile Matter.	x
Coal II	5.94	25.99	12.38 (*a*)
" III	6.82	28.30	35.98 (*b*)
" IV	8.73	32.17	63.51

(*a*) This should be 13.39; there is a misprint in the original paper.
(*b*) The alternative value 14.1 may be quoted.

Lewes reproduces Euchene's figures (Table III.), and states: "These results show in a striking way that the heat liberated increases in nearly regular ratio with the amount of volatile matter in the coal, and that the more oxygen the coal contains the more endothermic its reaction, a fact which points clearly to its being the oxygen-bearing compounds in the coal which give it its endothermic character." We have been interested to ascertain how far Constam and Kolbe's results support these hypothesis. These results are summarized in the following tables.

TABLE IV.—*English Coals.*

	Net C. V. in B T.U.	x = per Cent. C. V.	x in K.C.U. per k g. Dry Ashless Coal.	Volatile Matter.	Oxygen.
Nottingham	13,918	6.0	463	42 63	10 20
" (best hard)	14,072	4.4	343	39.60	9.24
Low main	14,859	4.0	329	36.01	5.66
Ballarat	15,109	3 6	303	26.40	4.22
Kinneil	14,494	3.5	282	38.40	....
Trencherbone	14,602	3 1	252	39 96	7.05
Hutton	15 235	2.9	246	33 14	3.70
Barnsley	14,324	2.5	199	33.26	7.92
Nixon's	15,271	2.1	178	21.52	2.58

The relationship between the volatile matter and x is not good, and two coals (Trencherbone and Barnsley) are out of place if the oxygen content is considered.

TABLE V.—*Continental Coals.*

	Net C. V. in B.T.U.	x = per Cent. C.V.	x in K.C U. per k.g. Dry, Ashless Coal.	Volatile Matter.	Oxygen.
Pyrenean	13,563	6.68	501	42.85	....
Gardanne	12,446	7.2	493	49.40	14.0
Mausegatt	15,073	5.67	475	12.62	....
Bruay	14,196	6,0	473	37.90	....
Gladbeck	14,562	5.76	465	31.86	6.3
Sonnenschein	15,282	5.1	433	19.07	....
Girondelle	15,120	4.93	413	15.59	....
Amercoeur	15,237	4.8	407	9 88	1.73
Ronchamp	15,094	4.5	377	22.10	....
Blanzy	14,097	4.8	376	34.60	....
Epinac	14,954	4.4	365	10.85	....
Chapelle-sous-Dun	13,415	4.4	328	43.40	....
Lenz	15,030	3 7	309	28.00	....
La Mure	14.551	3,6	291	7.40	1.36
St. Etienne	15,046	3.3	276	29.65	....
Ostricourt	15,121	3 2	269	10.35	....
Flöz Robert	15,120	3.01	253	22.40	....
Grand Combe	14,814	2.6	214	20.20	....
Meurchin	15,192	2.2	185	12.65	....

In Table V. there is no agreement between the volatile matter in the coal and heat evolution (x); but the four cases in which the oxygen content is given support Lewes' hypothesis that the oxygen-bearing compounds in the coal are responsible for the heat evolution. When one considers the exothermic nature of many of the oxygenated compounds found among the distillation products, it does not seem improbable that the oxygen-bearing compounds in coal are in part responsible for the heat evolution, but in this connection it should be remembered that some of the other products including methane are also highly exothermic.

Summarizing the relationship between the calorific values of coal and its distillation products; it appears that the distillation is exothermic when the calorific values are determined at ordinary temperatures (a convention in thermo chemical tables), but we consider that the question is still open so far as concerns the net total heat evolved or absorbed during the actual process of carbonization at the temperatures used. Our own work was not particularly directed towards the determination of the net quantities of heat involved in distillation, but, having regard to the complicated sequence of reactions which inevitably occurs, was an attempt to see how far it was possible to divide the process into thermal stages, heat absorbing, heat evolving and thermally neutral.

The method we employed consisted in heating side by side, under the same conditions, a coal which underwent carbonization and a coke which could be regarded as chemically and thermally inert, and noting by means of differential thermo-couples the extent to which the temperature of the coal became higher or lower than that of the coke in various stages of the distillation. Complications arising from the secondary decomposition of distillation products were minimized by using a small quantity of coal and sweeping away the products by a stream of inactive nitrogen. These precautions would modify such thermal changes in the interior of a large mass of coal undergoing carbonization as have been observed by Bond.

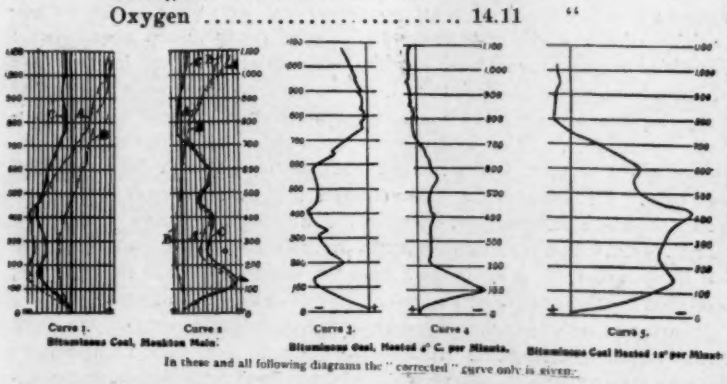
The coal and coke were heated in very thin fireclay boats through which pass long thin silica tubes giving necessary protection to the thermo-couples. The coke standard is previously prepared by packing one of the boats with coal and then heating it to a temperature of

1,100° C. in an atmosphere of nitrogen. The combined length of the two boats is about 6 cms., and a preliminary trial showed that the temperature of the furnace was satisfactorily constant over that range. After a few experiments had been made, 7° C. per minute was found to be the most suitable rate of heating; but it was found to be important to maintain a very uniform rate of heating throughout the experiment. This was done by gradually increasing the current passing through the furnace by decreasing an external resistance in series with the furnace. To increase the possible delicacy of adjustment of the current passing through the furnace, one rheostat was connected in parallel with the furnace. Also special arrangements were made for the supply of current at a very steady voltage.

In the selection of a standard body alongside which the coal may be heated, there are two main considerations. The body should have a thermal capacity not very far different from that of the coal, and it must be capable of being raised in temperature at a perfectly uniform rate—*i. e.*, it must not exhibit any thermal changes itself. Powdered coke was at first used but was soon abandoned in favor of a standard which has been prepared from coal packed into the boat as already described. The coal shrinks during the later stages of carbonization, and thus a very good contact is obtained with the tubes surrounding the thermo-couples. At the outset, a suitable vessel had to be found in which to heat the coal. As nickel exhibits no serious thermal change, boats made of nickel gauze were at first tried; but it was afterwards found much more convenient to use the fireclay boats with lids of nickel gauze.

The coal which was examined in most detail is a sample of the picked nuts from the Monckton Main seam, the composition of which is as follows:

Volatile matter	40.2	per cent.
Ash	5.43	"
Carbon	72.36	"
Hydrogen	4.93	"
Sulphur	1.64	"
Nitrogen	1.53	"
Oxygen	14.11	"



In these and all following diagrams the "corrected" curve only is given.

In the above diagram the dotted curve *A* represents the actual heating curve of the coal, each dot representing a minute reading, and the deflecttons on the + side of the vertical zero line show that the coal is hotter than the coke and *vice versa*. Each division to the right or left represents a deflection of 2 mm.—*i. e.* (assuming the electro motive force of each couple to be a linear function of the temperature) a temperature difference between coke and coal of 1° C. These divisions are not inserted in the following curves, but all are drawn to the same scale.

One cannot be quite certain that, independent of the changes which take place in the coal, the two differential thermo-couples will be raised in voltage at the same rate. The two couples were made from the same batches of wire, so that they should give as nearly as possible the same voltage at the same temperature. But there are other possibilities. The constant range of the furnace may not be the same at all temperatures; and there may be some difference in the heat conductivity of the boats and of the silica tubes surrounding the thermo-couples. Therefore, in all cases after obtaining the curve A the furnace was allowed to cool, and a blank curve was taken by repeating the heating. Thus the dotted curve *B* represents the heating curve of the two cokes—*i. e.*, the coke standard in the one boat and the coke made in the other boat during the experiment. Now if the curve *V* is subtracted from *A*, we obtain the curve *C*, which represents the changes which take place during the distillation of the coal. The validity of the correction due to the blank curve *B* has been repeatedly tested by reversing the positions of the coke standard and the coal in the furnace. Thus the standard used for Curve 1 was replaced by fresh coal, which was heated alongside the coke resulting from the distillation of the coal used for Curve 1. The correction was obtained and applied in the same manner as before, and it will be seen that in general characteristics Curve 2*C* is the reverse of Curve 1*C*.

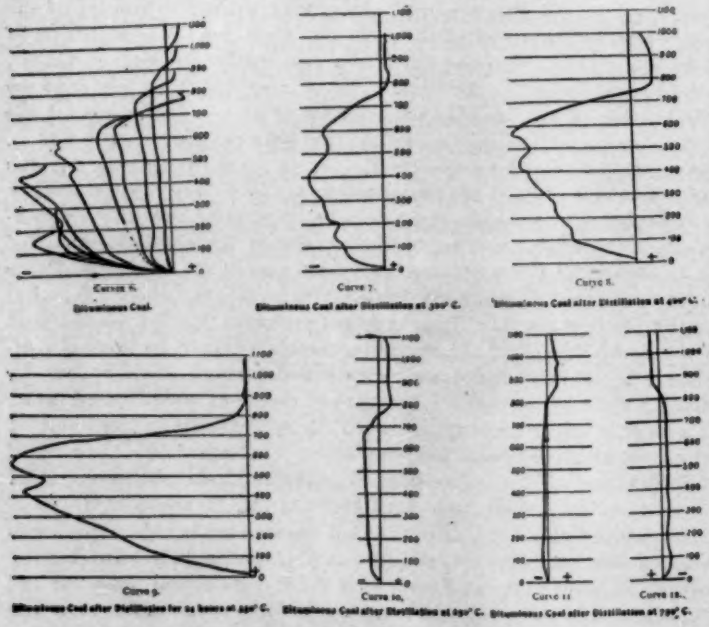
Referring to the corrected Curves *C*, it will be seen that at first the coal lags behind the coke in temperature, probably because of the lower heat conductivity of the coal. It is not due to the expulsion of moisture, since in all cases the coal was dried for one hour at 110° C. before being placed in the boat. The turning point occurs between 100° C. and 150° C., and the explanation of this presents some little difficulty, since it is hardly possible that between 150° C. and 250 C. there can be any exothermic reaction in an inert atmosphere. It was noticed that the extent of the deflection at 150° C. varied considerably in different experiments; and this is believed to be due to the uncertainty in the rate of heating of the furnace at the commencement of an experiment. Owing to the very rapid rise in the resistance of the furnace, it was found almost impossible to secure uniform heating during the first 200° C. Thus it seems probable that the second part of the curve up to 250° C. simply represents a return to normal condition. In all cases there is a very decided turning point at 250° C., showing the start at that temperature of reactions which absorb heat. This stage is interrupted at about 420° C. by a change in the slope of the curve which indicates heat evolution. Between 460° C. and 610° C. there seems to be another stage representing heat absorption; then the heat evolution continues until between 750° C. and 800° C.

The Rate of Heating.—A curve (not reproduced in this paper) was obtained when the rate of heating was 2° C. per minute. In this the distillation takes place so slowly that there is sufficient time for the temperatures of the coal and coke to become equalized before the temperature of the coal (relative to that of the coke) can be altered to any marked extent by internal changes. Hence we do not find in this curve the large deflections noted with the quicker rates of heating, and the curve obtained does not exhibit any marked changes. The only turning point of which there is any distinct evidence is that at 750° C. When the furnace is raised 4° C. per minute (Curves 3 and 4), the turning points are more marked; but there is still a difficulty arising from the tendency to irregular heating. When raised 12° C per minute (Curve 5 a smoother curve is obtained, since the maintenance of uniform heating is easier; but at this rate of distillation it is doubtful whether sufficient time is allowed for the completion of changes which normally take place at a given temperature before that temperature is considerably exceeded. Thus in Curve 5 it will be seen that the turning point usually found very little above 750° C. was about 800° C. These considerations led to 7° C. per minute being adopted as the standard rate for raising the temperature; and all the curves reproduced were obtained at that rate unless otherwise stated.

The Possible Influence of Conductivity.—The question might be asked whether the different slopes in the curves really represent the absorption and evolution of heat due to chemical changes during distillation, or whether they represent successive changes in the heat conductivity of the coal during distillation. A special series of experiments was carried out to investigate this question. The heating curve was taken in the usual way up to 200° C. The furnace was then allowed to cool immediately, after which a heating curve up to 300° C. was taken. In this way, each successive heating of the same coal was taken 100°C. higher up to 1,100° C. The curves obtained (corrected in the usual way) are platted together for comparison (Curve 6). It has already been pointed out that the difference between the conductivity of coke and coal largely determines the magnitude of the initial deflection. Hence if any marked change in conductivity takes place at any given temperature, we might expect a marked difference between the early part of a curve obtained before the coal had been heated to that temperature, and the early part of a curve obtained after the coal had been heated. Curve 6 show that (excepting, possibly, at about 300° C.) throughout the distillation there is a steady improvement in the conductivity of the coal. The most marked improvements are noticed after heating to 500° C and 600° C., which is quite in accordance with what might be expected when it is remembered that the caking of the coal takes place at about that temperature.

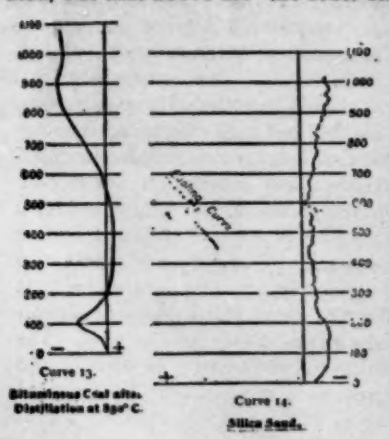
It was thought that if a small difference in conductivity could account for the deflections noted in the heating curve of coal, very large deflections would be noted if the coke was heated alongside substances of such a low conductivity as ignited powdered-fireclay or ignited silica sand; but it was found that the deflections obtained in such experiments were quite small. These experiments led us to

conclude that the heating curves of the coal were not unduly complicated by the varying heat conductivity of the coal and further confirmation of this was received by the very similar behavior, on heating, of coke as formed in the boat in one piece, and of the same coke powdered and filled loosely in the boat.



Stages in the Heating Curves.—One attempt to elucidate the various phenomena consisted in heating the coal up to various temperatures suggested by the heating curves, under conditions similar to those under which the curves were obtained, and determining the loss of weight in the coal; but all that could be learned was that when the coal is raised in temperature 7° C. per minute, the maximum rate of loss in weight occurs at a temperature of about 400° C.

It has already been pointed out that the first stage of the curves up to 150° C. is believed to be due mainly to the lower heat conductivity of the coal. It was found that about four hours' drying of the coal in the furnace at 100° to 110° C. immediately prior to taking the heating curve did not affect the general character of the curve. Curve 7 shows the result obtained after previously distilling the coal for six hours at 300° C. The stages in the curve below 300° are only partially obliterated, and it would seem that six hours is not a long enough period for the completion of the changes taking place below 300°. Curve 8 is the heating curve after previous distillation for three hours at 400° to 414° C. Again, one cannot be certain whether the preliminary heating has completed the changes which take place below 400°. Curve 9 is much more decisive. It shows the heating curve obtained after a preliminary distillation for 24 hours at 350° to 360° C. In this curve we see that the stages below 400° have been obliterated, but that above 400° the other stages are still quite clear.



If the interpretation given for curves 6 be accepted, these stages in the heating during which the coal tends to increase in temperature more rapidly than the coke are not simply the result of an improving heat conductivity of the coal; but it was considered possible that they represented a return to normal condition—that is. an equalization of the temperatures of coke and coal—immediately after an endothermic stage of the distillation process. It was largely to investigate such possibility that these particular experiments were performed. In curve 9 we find that the stage between 420° and 470°, still persist in spite of the fact that all distillation at 360° must have been completed before this curve was commenced. It seems, therefore, to be established that exothermic changes do take place between 420° and 470°.

Proceeding in a similar manner to the 610° and 750° stage, Curve 10 was obtained after a previous distillation at 600° to 650° for three hours. In this case all changes below 650° are obliterated, but above that temperature the exothermic stage continues. It was thought desirable to ascertain if 24 hours' distillation at 650° would complete this exothermic stage; but the curve obtained (not reproduced) showed that such was not the case.

Curve 11 was obtained after previous distillation for 3 hours at 750°; and it is very significent that even in this case the exothermic stage still continues up to 890°. Curve 12 was obtained in confirmation of this observation. Curve 13 shows that 3 hours' distillation at 850° has almost obliterated all thermal changes.

Referring to Curve 6 (actually obtained after 11, 12 and 13), it will be seen that there again the exothermic stage continues up to higher temperatures after a preliminary heating. (In this case the heating was not prolonged at any temperature, and thus we still find evidence of the exothermic change even after a preliminary heating to 1,000° C.)

A possible explanation of these results is that the exothermic reactions start at 610° C. and continue until some high temperature is reached, but that at about 750° there start other endothermic reactions, which in the ordinary heating curve mask the exothermic effect above the temperature. Further, while prolonged heating at 750° does not effect completion of the exothermic reactions, it would seem that it does complete the endothermic reactions, since after a preliminary heating at 750° there is evidence of exothermic reactions up to 900° C.

Summary and Conclusions.—The heating curves of coal obtained in this research do not afford any quantitave data as the net thermal result of carbonization; but it would seem that the *net* quantity of heat involved is very small, since there are balancing exothermic and endothermic reactions taking place. At certain temperatures it is not improbable that both exothermic and endothermic reactions take place simultaneously, thus considerably increasing the difficulty of detecting such thermal changes by the experimental method employed. One interesting fact is that in no case have we found any evidence of a sudden decomposition at any definite temperature, such as occurs in the exothermic decomposition of cellulose. The decomposition of coal appears to consist of a very complicated sequence of reactions which extend over a wide temperature range. In the case of Monckton coal the distillation, so far as it is revealed by thermal changes, commences at 250° C., and endothermic reactions predominate up to 410°. This is followed by a short exothermic stage between 410° and 470°, and a second endothermic period between 470° and 610°. The exothermic stage above 610° C. is always very pronounced, and is interrupted between 750° and 800°. We are continuing our experiments to the examination of different coals, and so far as we have gone, it may be said that the same stages are in evidence, modified by the nature of the particular coal under consideration.

In attempting to explain the various phenomena observed, we have encountered considerable difficulty owing to the lack of chemical data respecting the products evolved from coal at different temperatures. Such fractional distillations under experimental conditions comparable with ours as have hitherto been carried out, have been between quite arbitrary temperature limits and most attention has been given to the permanent gases evolved; whereas those phenomena, chemical or physical, which give rise to the expulsion of vapors condensing to liquids on cooling may be accompanied by thermal effects at least as large as those caused by the expulsion of permanent gases.

Burgess and Wheeler in their study of the volatile constituents of coal have shown that there is a critical point in the distillation of coal at some temperature between 750° and 800° C., and that when that point is reached there is a large and sudden increase in the quantity of hydrogen evolved, while methane is more prominent among the products evolved at lower temperatures. Although methane is an exothermic body—*i.e.*; it is formed synthetically with an evolution of heat—It by no means follows that all the reactions which give rise to its formation are exothermic.

It is an interesting point that the figures of Euchéne, Mahler and Constam and Kolbe for the heat quantities evolved in the carboni zation of coal are of the same order of magnitude as the heat quantities, which can be calculated as likely to be involved in the formation or decomposition of methane. In the interpretation of results obtained in this research, it should be remembered that complications arising from the secondary decomposition of volatile products after leaving the mass of coal have been eliminated, but it is impossible to say how much secondary change takes place within the pores of the newly formed coke. It seems quite probable that the heat evolution

noticed above 610° C. in our heating curves may be connected with those reactions which give rise to the production of methane It has already been pointed out that this heat evolution is not due to one single reaction, but to a sequence of reactions. These reactions are interrupted at about 750° by others which give rise to the formation of large quantities of hydrogen. It is hoped that as more chemical data respecting the sequence of chemical changes which take place during carbonization become available, a more complete explanation of the results of this research will be possible. Further, the critical points noted in the heating curves may suggest temperature at which it would be more profitable to carry out fractional distillations.

As a further attempt to elucidate the phenomena observed, we propose to obtain the heating curves of those portions of coal soluble and unsoluble in pyridine or other solvents, and of substances of known composition.

The Firefly and Other Luminous Organisms.

[From a paper by F. A. McDermott, read before the Pittsburgh Section Illuminating Engineering Society.]

Expressions of vital energy as heat, sound and motion, are so generally known that the ordinary observer pays but little attention to them; the production of electricity is so rare a property of living tissue that it is not likely to be encountered by more than a very small fraction of mankind. Between these two extremes stand the forms which have the power to produce light—sufficiently widely distributed among the creatures of the earth to be seen by the majority of mankind, and yet sufficiently rare to excite the amazement and curiosity even of those who may daily observe them. There are representatives of the luminous organisms in both the plant and animal kingdoms. In the plant kingdom the luminous species are confined to a few bacteria and fungi; the reported cases of luminosity in higher plants are either doubtful or of a different nature. In the animal kingdom, however, the property is much more wide spread. Starting from the lowest forms, the unicellular protozoa, one finds the tiny Noctiluca, to whose presence in vast numbers is due the so-called phosphorescent sea; a number of other marine protozoa are luminous, and above these are luminous members in almost every plane of development up to and including the fishes. Among commonly known forms which have luminous species are the insects, fishes, centipedes, crustacea, cuttle-fish, star-fish and worms. To many people the various species of fireflies and glow-worms are the best known luminous animals. Most of my own work has been with these insects, and what I have to say relates principally to them.

With our ordinary light sources, in which the light is produced by heating some refractory body to incandescence, only a relatively small amount of the total energy supplied is radiated within the limits of the visible spectrum, the remainder being expended in infra-red and ultra-violet radiation, useless for illumination. By the use of substances showing selective radiation, as the Welsbach mantle, the mercury arc, and the flame arc, we have been able to increase the proportion of energy expended in radiation within the limits of the visible spectrum, but as yet we have not secured a source of light showing selective radiation entirely confined to the visible spectrum. This the firefly has accomplished.

Several investigators have subjected the light from various luminous organisms to spectrum analysis, and for the most part the results have been in close agreement. The first really extensive work was the bolometric study made by Langley and Very in 1890, on the Cuban cucuyo, in the Allegheny Observatory. They found that the light of this insect gave a continuous spectrum lying between 468 and 640$\mu\mu$, with a maximum at 530μ, and giving no hint of continuation in the infra-red and ultra-violet. They concluded that the light had an illuminating efficiency of practically 100 per cent. In 1908–9, Drs. Ives and Coblentz, in the United States Bureau of Standards, submitted the light of the common firefly to spectrophotographic analysis, and found it to consist of a structureless, unsymmetrical band, extending from 500$\mu\mu$ to 670$\mu\mu$, with a maximum of 570$\rho\rho$. Both the entire band and the maximum are thus shifted toward the red as compared with the light of the cucuyo. They estimated the illuminating efficiency of the light as about 96.5 per cent.; this figure has since been reduced to about 90 per cent. by later studies by Dr. Coblentz. As Ives and Coblentz remark, the firefly has carried the matter of efficiency in light-production too far for human needs, as such a light would, on account of its color, be even less desirable for general illumination than the mercury-vapor arc. The light emitted by the various species of firefly and glow-worms is usually stated to be yellowish-green, green, or bluish-green; the light of the luminous bacteria is similar. This is easily seen to be due to the distribution of energy in the spectrum, the maximum usually falling in the yellowish-green section, and being very sharp, the curve falling off rapidly towards the ends of the spectrum. However, all luminons creatures do not emit light of the same color- Dr. Coblentz has studied spectrophotographically the light from several species of fireflies from the neighborhood of Washington, and has shown that while the spectra are similar, there are differences between them. One group of glow-worms give a reddish light, in which the unusual tone does not appear to be due to absorption; and some marine forms, notably one deep-sea cephalopod, give lights of various colors. Further studies by Ives and Coblentz have failed to show any evidence of ultra-violet or infra-red radiation. One observer (Forsyth) claims to have found ultra-violet rays in the light from one species of basterium; but the result is at variance with other studies on this point and requires confirmation. Dr. Coblentz's recent work shows that luminous portions of the firefly whether giving light or not, are at a very slightly higher temperature than the rest of the insect's body.

Coblentz has studied the transmissivity of the chitin covering the luminous apparatus of the firefly, for wave-lengths not included in its spectrum, and finds that were these wave-lengths generated, they would not, for the most part, be absorbed by the chitin.

Ives and Coblentz estimated the watts-per-candle efficiency of the firefly at about 0.02; Ives and myself have obtained 0.054, using a different basis of calculation. This is about ten times as good as the nitrogen-filled tungsten lamp. Ives and Jordan give the intrinsic brightness of the glow-worm as 0.0046 candle-power per cubic centimeter. (Their glow-worm was the young of the firefly.)

A number of observers have stated that the light of the firefly, luminous bacteria, etc., shows penetrating effects similar to those produced by X-rays and radium. This phenomenon, which was so puzzling for a while, has been found to be due to traces of peroxid of hydrogen, or some other volatile peroxid, produced either by the organisms themselves or the medium upon which they grow, and which affect the photographic plate very strongly. It is of interest to note that cultures of luminous bacteria in a state of activity do not affect a charged electroscope, nor does the firefly affect the fluorescope.

With the progress of science in general, various theories have been advanced to account for the phenomena presented by luminous organisms. The first theory was that the light was due to the presence of free phosphorus; this theory is really without any sound scientific basis. Another view assumed phosphine to be the active material, and this theory also has fallen, owing mainly to the fact that no phosphine or similar compounds can be found. The idea that substances similar to the phosphorescent alkaline earth sulphides might be present has also been advanced and abandoned for lack of proof. It may be said in passing that the light of living forms has but little in common with that of the so-called phosphorescent sulphides. At the present time there is but little doubt that the light is produced by the oxidation of some complex physiologic product by means of the oxygen of the air. This specific substance would doubtless not prove to be the same in all luminous species. No one has so far succeeded in isolating the substance in the pure condition, and our knowledge of the chemical structure is necessarily limited. It seems probable, however, that it belongs to the class of biologic substances known as nucleo-proteins, possibly a nucleo albumin. The presence of fatty substances combined or closely associated with the nucleo-protein is also probable.

The question of the intimate mechanism of the luminous process is closely related to the general problems of respiration and the oxygen requirement of the living cell, and also with the problems in the field of autoxidation.

In practically all cases so far studied, three factors appear to be necessary for the production of light; water, oxygen, and the substance oxidized. The role of water is of considerable interest. Over 100 years ago it was found that if the luminous tissues of certain forms be dried, they could be made to give light again, simply by moistening in the air. This observation has been applied to a considerable number of organisms, and in experiments by Prof. J. H. Kastle and myself, it was found that if the luminous tissue of the firefly be dried in vacuum over sulphuric acid and sealed out of contact with the air, it can be kept for over 2 years without any apparent diminution of its activity. After moistening once, if the tissue be carefully dried, it may be made to give light a second or even a

third time. While dry the material may be heated to 100° C. without losing its activity, although a temperature sufficient to coagulate albumin destroys the activity of the moist tissue. Cultures of luminous bacteria may be dried and give similar results. Liquid air does not destroy the activity of either the fresh or dried tissue. even when the latter are ground in it. Luminous bacteria may be exposed to liquid air, or even liquid hydrogen, for a short time, without losing their power to grow and produce light upon return to normal temperatures; however, prolonged exposure, or grinding at the low temperature served to prevent growth and luminescence upon restoration of normal conditions. In its general conduct the tissue shows some similarity to the ferments and enzymes, and this brings us to Dubois' enzyme theory of light production. He thinks that the light is due to the oxidation of a nucleo-albumin by the oxygen of the air, through the action of an oxidizing enzyme or soluble ferment. It cannot be said that the theory is definitely established, but it certainly has much of interest in it. The question as to whether the process is really an oxidation or not was argued to and fro until recent years, but there is at present but little valid evidence opposed to the oxidation theory. It is of interest to note in this connection that if, when experimenting with the dry material, a hydrogon peroxid solution, instead of water, is used to moisten it, the resulting light will be quite a little brighter than with water. Dubois also found that solutions of certain oxidizing agents could replace his oxidizing enzyme solution.

The effects of various physical and chemical agents on the tissues are of interest, and much of the work that has been done on the problem has been along this line. In general it may be stated that the tissues are very irritable, and that light emission is produced in the resting tissues by mechanical stimulation, heat within certain limits, and electrical stimuli. The action is usually the same whether the living insect or the freshly detached luminous tissue be used. Chemical irritants and poisons are very active in producing light emission; practically all poisons, even though they kill the creatures, cause light emissions first—that is, the first effect is a stimulation, as the action of poisons on other physiologic functions. The vapors of ordinary alcohol, wood alcohol, chloroform, carbon tetrachloride and carbon bisulphide are especially active when applied in the presence of air to the freshly detached tissue of the firefly, causing flashes of light similar to the normal coruscations of the insects, while most other stimuli cause a continuous and sometimes rather a faint glow. Oxygen, either alone or when charged with ozone, though more active than air, does not act as strongly as might be expected from the statements made above as to the process being an oxidation. Nitrous oxid is about as active as oxygen. The one exception to the stimulant action of poisons is sulphur dioxid. In the great majority of cases where this gas has been used, an immediate and permanent destruction of the light producing power takes place, only occasionally a faint light-emission preceding the poisonous action. Iodin cyanid, bromin, and a few other compounds act similarily, but less powerfully.

In is conduct toward chemical stimulants the dried tissue, after moistening, acts in practically the same way as the fresh tissue. When heated above a certain temperature, the fresh, moist tissue loses its power to produce light. This temperature varies with the species, but evidently represents the point at which the albumin coagulates.

Many of the luminous bacteria are marine in origin, and will not produce light in the absence of sodium chlorid or some similar compound in the same concentration as found in sea-water—about three per cent. These organisms will grow and produce light in extremely simple media; a three per cent. solution of common salt containing one per cent. of asparagin will serve in some cases. Coblentz and Lund both mention the expansion of the luminous material of the firefly; apparently a supply of this substance is not continually formed during the life of the insect, but the creature begins its adult life with a limited capital of photogenic substance.

Many of the lower unicellular forms do not appear to possess definite organs for the production of light, the property being a general one of the entire cell. Still higher protozoa show a localization of the light-producing power in certain points on the cell; this is the case in Noctiluca, the organism causing the "phosphorescent" sea. With increasing complexity of the organism as a whole, the luminous apparatus become more and more complex, reaching its maximum in the fireflies and the fishes. In some creatures, the luminous organs are glands which excrete the photogenic substance directly into the air or water, where it is oxidized and gives light; in others the substance is burned within the organism. In this latter class belong the fireflies. The luminous tissue of the firefly consists chiefly of two layers, the inner one white and opaque, the outer yellowish and translucent. Both layers are penetrated by a large number of air passages which are indistinguishable in structure from the breathing trachea, and which unite with the latter at the breathing orifices. These air tubes pass without branching through the inner layer outwards into the outer yellowish layer, where they throw off numbers of fine capillaries, the latter forming a close network through the tissue.

The white layer appears to consist of compounds of or related to uric acid; the yellow layer apparently consists of the photogenic substance with its supporting tissue. According to the work of Lund, the luminous process is accomplished with the desposition of the white material from the yellow, the chemical tests indicating the breaking down of nucleic acids. Lund also studied the blackening of the luminous tissue by osmic acid, and concluded that a substance having the nature of a reductase (reducing enzyme) was present. In certain fish, crustaceans, cephalopods, etc., one finds a very remarkable form of luminous organ. It is only within comparatively recent time that man has learned to direct a beam of light forward by means of lenses and reflectors, but the animals just mentioned have been doing so doubtless for geological ages. They possess photogenic organs having a "bull's-eye" or "searchlight" structure, consisting of a reflecting layer—not infrequently having an approximately parabolic longitudinal section—with a light-producing body located at the focus, and provided with a lens. For many years the true character of these organs was not known, and they were referred to as auxiliary eyes, but in a number of cases they have been seen producing light, establishing their function beyond question. In the marine forms the oxygen necessary for the luminous process is supplied through a net-work of blood vessels similar to the net-work of air-tubes in the fire-fly.

The luminous organisms present many interesting problems in phylogeny, but we can say but little about this phase beyond the fact that the power to produce light appears to be a very primitive propty of living cells, and that the existing forms present some remarkable instance of convergence. Almost the first question that a good many people will ask regarding the firefly is "What good is the light to the insect itself?" In the fireflies the light-producing power serves to bring the sexes together for mating, and is essential to the maintenance of the species. The same probably holds for most luminous insects, and probably for other forms to some extent. There are known cases, however, where the utility of the power appears to be entirely that of luring prey, or discouraging the attacks of enemies. In many of the simpler forms no adequate explanation is apparent at present. The females of the fireflies use two forms of light emission which may be designated as "direct" and "indirect" illumination. Our ordinary species use the indirect method, that is, the illuminous apparatus is on the ventral side, and the insect clings to the grass or earth with the luminous apparatus directed downward, and when she flashes, the male sees not the luminous apparatus itself, but the reflection of the flash on the ground or foliage. Other species have the luminous apparatus of the female on the dorsal side, and in one species, the insect curls the abdomen over the back, so as to expose the luminons apparatus upward—the direct system.

It must be said that at this time there is little upon which to base a hope of the future practical application of physiologic light. It has been suggested that cultures of some of the more brightly luminous bacteria light be utilized as illuminants in coal mines, powder magazines, etc., but the cost would of course be prohibitive at present. We do not know the nature and constitution of the photogenic material, and even if we did, the synthesis of the material in the laboratory or commercially would probably be an enormously expensive process. A large number of chemical reactions which produce light are known—mainly oxidations taking place in an alkalin solution. However, the light is in most cases quite feeble, and very expensive.

Eighth Annual Convention, Illuminating Engineering Society.

Cleveland, O., Sept. 21st to 26th, 1914, has been selected for the I. E. S. Annual Meeting. Just a block from the Hollenden, Hotel Headquarters, lies Cleveland Public Square.

This is a stretch of land covering 10 acres in the heart of the city, set aside at the founding of the city as a breathing spot, which seems doubly necessary in the day of sky-scrapers, as you can see it is now surrounded by immense buildings.

Practically all the street car lines in the city terminate here, facilitating the transfer of passengers from one line to the other. Little

trouble will be experienced by those not acquainted with the lay out of the city in getting about by trolley, for a walk of one block from Hotel Headquarters makes it possible to reach any location desired either direct or by transfer for 3 cents.

The entertainment this year will be more pretentious than ever before. A list of papers submitted gives some idea of the knowledge that may be gained by meeting the authors and hearing and participating in the discussions.

Titles.	*Authors.*
Factory Lighting	Hogne and Dicker.
Some Experiments with the Ferree Test for Eye Fatigue	J. R. Cravath.
Planning for Daylight and Sunlight in Buildings	Marks and Woodwell.
Notes on the Ulbricht Integrating Sphere and Arc Lamp Photometry	H. K. Chaney.
Effects of Room Dimensions on Efficiency of Lighting Systems	Ward Harrison.
Relation of Light to the Critical Inspection of Documents	A. S. Osborne.
Experiments with Colored Absorbing Solutions for Use in Heterochromatic Photometry	H. E. Ives and E. F. Kingsbury.
A New Standard Light Source	L. A. Jones.
Artificial Daylight—Its Production and Use.	M. Luckiesh and F. N. Cady.
Characteristics of Gas-Filled Lamps	G. M. J. Mackay.
A Transmission and Absorbing Photometer for Small Areas	Nutting and Jones.
Recent Improvements in Gas Lamps	Welsbach Co. (author not stated.)
Illumination of Light Shafts	C. H. Sharp.
Portable Mine Lamp	H. H. Clark.
Some Recent Experiments on Vision of Animals	H. N. Johnson.
Light Filters for Use in Photometry	C. R. C. Moes.
The Locomotive Headlight	J. L. Minick.
Present Practice in Machine shop Lighting	Powell and Harrington.
The Development of Daylight Glass	E. J. Brady.
Lighting of the Home	Duquesne Light Co. (Author not stated.)
Lighting of the Carpet Mill	Ross and Ockley.
Color Variation in Illuminants	Jones and Nutting.
Reflection Standards	Nutting and Jones.
Physiological Effects of Light on the Body	E. C. Titus.

Don't forget the date (Sept. 21st to 26th), the place (Cleveland, O.) and the hotel headquarters (Hollenden).

Write early direct to the hotel to secure choicest accomodations, rates for room and bath start at $2.00

If you are not a member, come anyway, the Society will welcome you as a guest.

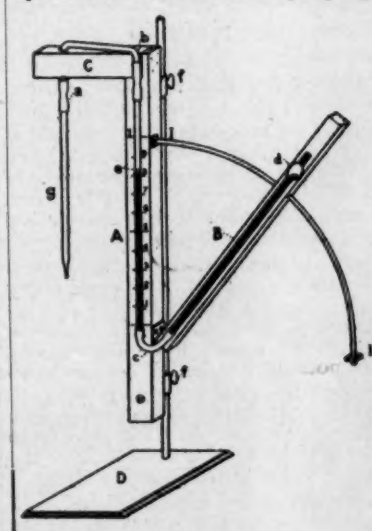
A Pipettometer.[1]

By W. D. Frost.

The pipettometer is a new piece of apparatus for measuring out precise quantities of fluids without the use of graduated pipets. It was originally intended for work in the bacteriological laboratory but will be of interest to those working in other laboratories. It consists essentially of an upright graduated glass tube with an upper side arm to which, by means of a piece of rubber tubing, ungraduated glass pipets may be readily attached. At the lower end of the graduated tube, another tube is attached by means of a flexible rubber joint.

This tube has a bulb at the outer end and is so arranged that the bulb end can be readily raised or lowered. The upright tube and the movable arm with bulb are partially filled with mercury. The whole apparatus is supported on a wooden or metal frame so attached to a ring stand that its height can be varied. By moving the bulb up or down, the height of mercury column in the graduated upright can be raised or lowered. When the mercury is lowered in this tube, the pipet draws up the fluid into which its tip is immersed and when it is raised the fluid is forced out. The amount of fluid taken up or discharged is measured by reading the position of the mercury in the graduated upright,

The details of the construction and its use can best be understood by reference to the accompanying figure. *A* is the support with its short arm *C* on the top and left, while *B* is the longer arm hinged at the bottom. The whole is supported on a ring stand *D*, to which it is held by the screw clamps *ff*. Mounted on this frame is the bent glass tube *abcd*, with a flexible joint at *c* and a bulb at *d*. When the arm *B* is moved up to position *I*, the mercury stands at 1.0, and when it is lowered to *II* the mercury stands at 0. A graduated pipet *g*, is attached at *a* and the *B* is raised to *I*. A vessel containing the fluid to be drawn into it is brought to the point of the pipet and the arm *B* is lowered to *II*. In this way, the fluid is drawn into the pipet *g*. It can then be discharged in whole or in part, slowly raising the arm *B*. The amount discharged is indicated on the scale. The graduations on the scale must be carefully made. This can be done by drawing water into *g* and then discharging it and weighing it on a fine balance. In this way the 0.5 and 1 cc. points can be determined. It will be accurate enough for ordinary work to mark off the intervening points. At first thought it might be supposed that all that it would be necessary to do would be to put a carefully graduated pipet in the system between *b* and *c*, but a little reflection will show that this would not be accurate, because the weight of the fluid in the pipet rarefies the column of air between the fluid in the pipet and of the column of mercury, so that not quite the proper amount of fluid is taken up. When, however, the graduations are once obtained, it is possible to measure any fluid very accurately if it has practically the same specific gravity as the fluid used in making the graduations The apparatus was originally made to handle 1 cc. lots and it was found that, with a little practice, quantities could be handled as quickly and accurately as with graduated pipets.



The tube *bc* can be replaced by a very small tube, in which case hundreths of a cubic centimeter can be easily measured; or it can be replaced by tubes of greater capacity which arrangement makes it convenient for measuring amounts of 10 cc. or more.

The Gas Machinery Company, of Cleveland, O., is installing a 9-foot water gas set at Binghamton, N. Y., for the American Light and Traction Company. The erection work is almost completed and the set should be ready for operation about August 20th.

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NOTICE TO ADVERTISERS.

New Advertisements and changes of copy therefor should be in hand Wednesday noon of week prior to date of issue.

NEW YORK, MONDAY, AUGUST 24, 1914.

[Official Notice.]

Michigan Gas Association Meeting.

Office of the Secretary-Treasurer,
Grand Rapids, Mich., June 29, 1914.

The annual meeting of the Michigan Gas Association will be held at Lake Harbor, Wednesday, Thursday and Friday, September 2, 3 and 4. This decision has just been made by the Executive Committee of the Association and we are sure those attending the meeting will find this departure from the regular practice of holding gas association meetings in the large cities, a most delightful experience.

Lake Harbor is a resort beautifully located on Lake Michigan and an inland lake 4 miles south of Muskegon, Mich. It is reached by Goodrich Boat Line via Muskegon, and by the Grand Rapids and Indiana Railway, and the Grand Rapids-Muskegon Electric Road via Grand Rapids. The hotel accommodates 500 guests, is prettily located and gives excellent service. There is a fine 18 hole golf course, baseball grounds, 9 tennis courts, Lake Michigan bathing beach, fine bath houses, bowling alley, billiards, canoeing and good automobile roads. There is a combination theater and convention hall which may be used for dancing parties as well as for the business sessions of the convention.

There are a number of cottages in connection with the hotel, and it is hoped that members will bring their wives and children, for the resort specially caters to the whole family.

At the time chosen, the association will have the resort practically to itself, and there is enough to do aside from a carefully planned business programme, which will be announced later, to make the trip worth while to any gas man within reachable distance of Michigan. Every gas man is invited to meet with us whether a member of the association or not. The hotel rates are on the American plan ranging from $3 a day without bath, to $4 and $5 a day with bath; and will for this occasion cover the use of the golf course, tennis courts and other features for which there is usually an additional charge.

Glenn R. Chamberlain, Secy. Treas.

BRIEFLY TOLD.

Michigan Papers.—The following are the papers announced for the Michigan Gas Association meeting at Lake Harbor, September 2, 3 and 4:

"A Coke Campaign that Increased Sales 75 per cent., by Richard C. Fowler, Detroit.

"A Talk on Service in Business," by Harry N. Tolles, Vice-President, Sheldon School of Salesmanship.

"Increased Cost of Gas," by John T. Young, Grand Rapids.

"Public Relations"—A report by Chairman of Committee on President Blauvelt's 1913 address, by V. F. Dewey, Detroit.

"Valuation"—An address, by Prof. H. C. Anderson, University of Michigan.

"The Electrical Separation of Tar from Coal Gas"—Second paper, by Prof. A. H. White, R. B. Rowley and C. K. Wirth, University of Michigan.

"Would Michigan Gas Plants Benefit from the Services of an Efficiency Engineer," by R. Shacklette, Big Rapids.

Trying for Efficiency.—Here is a municipal plant that aims to give service. The manager of the Holyoke (Mass.) Gas and Electrical Department has posted this notice:

The Public is Entitled to Courteous Treatment and to the best Possible Service."—Courtesy is the most valuable asset that an employee of this Department can possess. The best efforts of the Department to please its patrons are sometimes offset by the thoughtlessness of an employee who may fail to remember that any act of his which develops ill feeling re-acts upon the Department, and upon his fellow employees.

To Our Employee.—Courtesy is the outward expression of breeding and character. Do not forget that you are in the service of the public as well as of the Department.

Never attempt to take advantage of a patron.

This Department wants no revenue it does not earn.

This is not a "soulless corporation" and the conduct of each individual employee should so demonstrate.

To the Public.—Please do us the favor of selecting our office as the proper place to register complaints.

We are ready and anxious to investigate any "kick."

No individual or corporation can always be perfect.

We invite your help and ask your co-operation in bettering our service.

Tell This to Your Consumers.—"The gas bill seems to be one of the wasps of domestic life. It is so irritating that it is the one great source of universal grumbling; but do we take into consideration how guilty we are for our negligence and contributive ignorance? We curse the poor gas or the poor electric light when we paper the walls of our houses with paper which, instead of reflecting light, absorbs too large a proportion of it.

"A London authority says: 'Before we can look for anything like a sufficent return for the money we spend on light, all the rich dark tones, the deep crimson, which is so popular for dining rooms on account of the impression of warmth it gives, and the various shades of brown so much used in libraries and dens, must be replaced by pure white or very light shades which absorb a minimum of light.'

"It is a wonder the gas company does not call our attention to our stupidity. The color of the walls should aid illumination, not retard it. It isn't the fault of the domestic that the gas bills are so large always, for light is wasted by poor taste and judgment all the year round. Some wall papers are a continuous expense."

New Jersey State Gas Association Meeting.—The mid summer meeting of the New Jersey State Gas Association was held at Wardell's Port au Peck on the 12th inst., with about 60 in attendance, when President Butcher called the assembly to order at 10 A.M. Upon completion of the routine order of business, three papers were read: "Development and Possibilities of Gas Water Heating," by Mr. Herbert Long; "Newest Things in Gas Lighting," by Mr. J. P. Conroy; and "Auxiliary Heating," by Mr. Wm. Schofield.

Mr. Long's paper was enthusiastically received and thoroughly discussed, those participating being—S. J. Franklin, R. M. Garrison, W. F. Thomas, H. H. Newman, R. I. Wilson, H. G. Peck, J. M. Brock, R. F. Pierce, H. V. M. Dennis, C. S. Gravatt and F. R. Cutcheon.

Mr. F. N. Hamerstrom was to have presented a paper on the "Newest Things in Gas Lighting," but he was not present, and Mr. R. F. Pierce spoke extemporaneously on the subject, describing in detail the new Welsbach lamp just ready for the market. Mr. J. P. Conroy's paper on this subject which he called "Up-to Date Gas Lighting," dealt principally with the newer productions of the General Gas Light Company, particularly the new mercury valve for distant control of arc lights and new designs in semi-indirect fixtures. The points brought out by Mr. Price and Mr. Conroy were discussed together and much interest was aroused. Mr. J. P. Hanlan criticised

gas men in general for their seeming apathy and lack of interest in the new appliances developed by manufacturers. He said the average gas man is too willing to put it up to the other fellow to try the new things, with the result that often good efficient appliances remain unrecognized until our competitors, especially in the lighting field, have time to supply an electrical appliance as a substitute for the gas appliance that we failed to recognize and push. He advised giving the gas appliance manufacturers a chance by supporting them and trying out their new products, and, when found efficient, pushing them.

The President announced that 2 P.M. having arrived, it was time for dinner, and the Annual Bake, a feature of the mid-summer meetings, was then enjoyed. While the clams and things were being attended to the Golden Gate Quartette rendered a number of selections, and Mr. Joe Wooley gave some black face imitations and banjo solos. All agreed that this was one of the best meetings the Association has had. A committee was appointed to select time and place for next meeting, to be announced later, and the gathering adjourned.—P. O. F.

War and Our Mineral Resources.—Secretary of the Interior Lane is quoted as saying that direct benefit to the United States from the European war will be its effect in making us realize to a greater extent the values of our mineral resources. Of an importance second only to that of the food supply, is the supply of mineral products necessary to meet the requirements of 20th century civilization.

One of the first effects of the war has been to make us realize the independence of nations in the matter of food supply. Most of the countries now at war are dependent upon importation of foodstuffs, and we have cause for self-congratulation that we are able to feed ourselves. What we have possibly not so fully realized is that we are nearly as independent in the possession of essential mineral resources, and that interference with manufacturing caused by interruption of the flow of importations of many raw materials, may be overcome by development of neglected resources of our own. Business is established along certain well marked channels, and usually follows the line of least resistance. It has been easier, and perhaps cheaper, to import some mineral products and materials from other countries than to go to the trouble of developing our own resources of the same nature. Forced to the latter course by suspension of commerce with other countries, I believe that American enterprise and energy will turn to the development of the native supplies rather than permit production to lag and supply to be diminished.

The southern States have for years largely supplied the world with phosphates, but because of the distribution system, a large part of this supply has gone to Europe, and much of the phosphates used in the Western States have been imported across the Pacific. We have some 3,000,000 acres of phosphate lands in the West, near smelters, which produce sulphuric acid necessary to convert the phosphates into form available for plant food, and still there is no law by which these phosphate deposits can be made commercially available, although a bill which would allow of their immediate development has been favorably reported by the Public Lands Committee of the House of Representatives. At present these deposits and resources are locked up. To open them, when the supply of other countries are cut off, means to make American industries using these materials independent of the rest of the world, and business men will not neglect the opportunity to make our industries safe from the interruptions of war we are now experiencing.

The steel industry is affected. Manganese is of large importance to this industry, and the largest supply of ore is from Russia and other countries with which commerce is now paralyzed. There are, however, large undeveloped deposits in South America, but it is not necessary even to go as far as that, as we have great stores of manganese in this country, largely untouched because somewhat inferior in quality. To bring this home supply into use means merely adoption of successfully used methods for its purification, and we then can continue making manganese steel without regard to foreign sources of material. We have depended largely upon the island of Ceylon for the graphite used in the manufacture of crucibles in which steel for edge tools and small firearms is made. Or to take another metal, European smelters, using in part Chinese and Mexican ores, have in late years furnished much of the world's supply of antimony. War has paralyzed the production of antimony in England, and prices have gone up. Antimony, however, is easily extracted from many low grade ores found in great quantities in at least 7 States, and there is no reason why we should net make this extraction and be independent both as to supply and prices. Similar conditions hold in the case of arsenic.

A large tonnage of ferromanganese alloys comes from Germany and England. It is only in the last 10 years that we have freed ourselves from Sicily's monopolistic control of the sulphur supply. Flint pebbles are common enough in the United States, but for such an apparently unimportant product as these, used in the fine grinding of cement and ores, we have been depending upon the chalk cliffs of England, Denmark and France. Ores and mineral freight depend almost wholly upon the tramp steamer, a carrier of foreign parentage. Now the tramp steamer has taken to cover, and ocean freight, especially low grade freight, will be held up and its carriage almost entirely suspended during the war.

Importers, consumers and manufacturers are making anxious inquiries as to where they may find in the United States supplies of crude materials to replace the foreign supplies now shut off. This is the opportunity of the United States to free itself from dependence of its industries upon other countries, and business men are awakening to this fact. They look to the Government for aid in finding new sources of supply to keep the factories in operation. When they find a domestic supply and begin its use, they will not return to dependence upon the foreign supply, and thereafter the maintenance of industries will be more independent of foreign complications.

The Nation's greatest natural resources are a part of the public domain, and under the charge of the Interior Department. The annual reports on our mineral resources, published by the United States Geological Survey, contain statistics of yearly production of all commercial minerals and useful facts regarding their occurrence, exploitation and application in the arts and sciences. The Geological Survey will furnish upon request the addresses of producers from whom buyers can supply their wants, if the mineral is produced at all in this country, or information regarding the localities of reported deposits. In some instances large deposits remain undeveloped simply because distance from market has given to the foreign sources with low ocean freights an advantage over domestic producers shipping by rail.

What immediate effects upon mineral industries may be expected from the war? Already the copper industry has felt the injurious effect, and production has been curtailed. While considerable copper is consumed in munitions of war, the constructive arts furnish a far better world market. In the case of zinc, however, the effect is different. The smelting centers of Europe are in the zone of fighting in Belgium, and in Rhenish Prussia, Austria-Hungary and Russian Poland, and it is within the limits of probability to expect a loss of a half million tons in the foreign production of zinc, or nearly half the world's output, with beneficial effect upon the recent overproduction in the United States; especially as affording an opportunity to export zinc and galvanized iron products to South America, which market has hitherto been only in part utilized by our exporters.

Fuel oil has a large use in naval warfare, yet the tying up of the big tank steamers in Atlantic and Pacific seaports is already embarrassing the oil producers of the country who depend largely upon the export trade in all the forms of petroleum, crude and refined. On the other hand, Russia, our strongest rival in oil production, must suffer more complete and longer continued interruption of exports, which should tend to enlarge the market for our oil.

While the United States leads in coal mining, the nations at war are the six next largest coal mining countries, producing together over half the world's coal. Interference with their mining and commerce must increase the demand for our coal at least in neutral countries, and coal is our one resource about which there need be no present anxiety. The United States is now producing 40 per cent. of the world's supply, and the reserves not yet drawn upon exceed those of all the rest of the world combined. It is not generally known, however, to what an extent we are depending upon Europe, principally Germany, for the chemical products derivable from coal, and which we have been permitting to go to waste in the most reckless manner. Coal tar obtained in the manufacture of coal gas, and of coke in retort ovens produces hundreds of chemical products, but chemical industries using coal tar as a raw material have had little development in the United States. Our imports of coal tar products in 1913 were valued at $11,000,000 at initiating points and when they reached the consumer probably cost double that amount. If war continues any length of time we will have to do without aniline colors and dyes, certain drugs, and other coal tar products or American manufacturers must supply these essential commodities.

The Nomenclature and Definition of Photometric Magnitudes and Units.

[From a paper by A. P. TROTTER, presented before the Illuminating Engineering Society, London.]

At the Baltimore Convention of the Illuminating Engineering Society, October, 1910, a report was submitted by a sub-committee on photometric units. Another report was presented in December, 1912, submitting certain definitions to be tentatively adopted. The object of this paper is to examine these definitions and to elicit some discussion on them.

There can be no question about the scientific accuracy or logical exactness of a report coming from authorities so well known to all those who have made a study of the science and industrial applications of photometry, but questions may be raised about the terminology and the choice of units and the general scheme of the proposition.

The first and fundamental quantity chosen by this committee is as follows:

"*Luminous flux* is radiant power evaluated according to its capacity to produce the sensation of light."

The natural and obvious quantity would seem, to most of us, to be "candle power." This comes as the seventh quantity, and is defined:

"*Candle power*—luminous intensity expressed in candles."

This sends us to "luminous intensity," the fourth in the report, and is thus defined:

"*The luminous intensity* of a point source of light is the solid angular density of the luminous flux emitted by the source in the direction considered; or it is the flux per unit solid angle from that source."

None of these are simple, and the last appears to be a rather complex quantity, especially to anyone who knows little or nothing about solid angles or flux, but who *thinks* that he knows what is meant by "candle power." Twenty four years ago I wrote, "Light being an expenditure of energy, candle power is an accurate term, since it is the measure of the rate of expenditure of energy." To this it may be answered, "Why drag in energy?" Light is defined in most dictionaries and encyclopædias subjectively, as in the first definition of the U. S. Report of 1910. "Light is the stimulus produced by radiation, which excites vision." But light may also be defined objectively. The sensation of light is a subjective affair to which magnitudes and units cannot be applied. It is one of the elementary principles of photometry that the only ratio that can be visually determined is that of equality.

The sensation of light is the result of the stimulation of the optic nerve through the retina. This stimulation takes place when the frequency of the undulations of radiation is between about 4×10^{14} and 8×10^{14}, about one octave. Below this is infra-red radiation, above is ultra-violet. These infra-red and ultra-violet radiations, and mechanical pressure, will affect a photographic plate. Pressure and electric current also produce the sensation of light. Whether the range of the spectrum visible by man is different from that visible to other animals does not seem to have been investigated. For those who are not engaged in extending the borders of physics, the undulatory hypothesis of light still remains plausible and useful. Dr. Schuster has said that in the expressions we adopt to describe physical phenomena we necessarily hover between two extremes. We either have to choose a word which implies more than we can prove, or we have to use vague and general terms which hide the essential point instead of bringing it out; and he has said elsewhere that it is not necessary to wait until we can define the deplacements which constitute the waves before we attempt an objective definition of light. But this is not the place to discuss whether Kelvin and others were right or wrong in holding that radiant heat and radiant light are identical. Kelvin's statement—"If you see it, it is light"—will suffice for our present purpose.

The term "candle power" is used in two senses. In one sense it connotes an abstract idea like area or pressure, and in the other it is a vector quantity and denotes a definite magnitude. In the former sense it is synonymous with "luminous intensity," but has taken such a hold on the English language that it is difficult to get rid of it. In the latter sense, the name of the physical unit of luminous intensity, the "candle," may often be substituted for "candle power." Prof. A. Blondel shudders not only at our expression "candle power," but at our use of "candle" as a physical unit. "It is as unscientific," he writes, "to call the unit of intensity 'an international candle' as it would be to call the unit of electromotive force an 'international battery,' or the unit of heat an 'international stove.'"

This intensity, or strength, or power, or rate of emission of light is a simple vector quantity, although in some cases, such as in a thick mist, or in the upper part of a lighted candle, the direction is not possible to define. Assuming a sensibly transparent homogeneous medium, and a point source, the direction is radial to the source and the unit of intensity is that of one "candle." This, on account of its simplicity and its primary character, has strong claims to be regarded as the fundamental unit in photometry.

The expression "intensity" deserves some consideration. In the vocabulary of the Nomenclature Sub Committee of the British Electrotechnical Committee it is observed that "there is an increasing disposition to restrict the use of the word 'intensity' in English physical science to a ratio, the denominator being an area. The older meaning was synonymous with strength." According to the admirable logic of French thought, an electric current is a phenomenon. An ampere is not the unit of current, but it is a physical quantity and is the unit of the intensity of the current. In English we feel no necessity for the introduction of the word intensity, and we express the magnitude of an electric current in amperes.

These different usages, however, do not seem to afford a reason for defining luminous intensity or candle-power as the solid angular density of the luminous flux emitted by the source. I have shown in my book on "Illumination" that rainfall may be measured as a volume, or as an area of vertical section (as is usual in gauging the flow of a river), or simply as a height. The first way employs three dimensions of water and two of land; the second suppresses one of each of these dimensions and leaves two of water and one of land; the third again suppresses one of each of the dimensions, and leaves one of water and a mathematical point of land. There is no water left. True, but this is no objection, for the magnitude is not one of a quantity of water but of the intensity of rainfall. Another analogy into which the concept of a solid angle may be introduced, if we please, is afforded by a spherical vessel containing gas under pressure. Owing to the kinetic energy of the molecules a pressure is exerted on the sides of the vessel. A solid angle having its apex at the centre of the vessel, and subtended by one square inch of the internal surface of the vessel, may be considered, and it may be found that a pressure of 140 pounds is exerted on this square inch. This is a convenient mode of expressing the pressure. But the intensity of this pressure is exerted at every point on the spherical surface, measured, it is true, in pounds per square inch, but not needing a square inch, or indeed a surface of any conceivable magnitude, for it may simply be expressed as a pressure of 10 atmospheres or 300 inches of mercury. Similarly, the idea of a solid angle may be dismissed in considering the luminous intensity of a source of light; the idea of flux dentisty imports redundant dimensions. It may be said that here is a false analogy. Our practical unit is the pound, not the pound per square inch. True, but Everett furnishes the answer—it is a question of convenience, and the fundamental units should be easy of definition and of simple dimensions. The relation between a lumen and a candle-power is a mere matter of arithmetic.

The choice of luminous intensity or candle-power for the fundamental magnitude defers the concept of flux and solid angle until these are wanted.

The magnitude of second importance, but coming fifth in the list of the Committee, is "illumination." This is defined:

"*Illumination* on a surface is the luminous flux density over that surface or the flux per unit of intercepting area." Seeing the great industrial importance of describing, specifying, calculating, and measuring illumination, and seeing, too, that the units foot candle and *metre-kerze* are well established, it is unfortunate that a definition of this quantity should be proposed which is so difficult for a layman to grasp.

To understand what is meant by illumination, let us not generalise about the concept, but go straight to the units by which it is always measured. Illumination consists of two factors, candle-power and distance. The British and U.S. unit is the foot-candle. It is the illumination received from the source of one candle-power falling perpendicularly on a surface at a distance of one foot from the source.

In this definition it is desirable to use the words "received from" and not "produced by" in order to make a clear distinction between illumination and brightness.

The U. S. definition—"*Illumination* on a surface, is the luminous flux-density over that surface, or flux per unit of intercepting area

—and the definition of the unit, "*Lux*, a unit of illumination equal to one lumen per square meter," sends us wandering over the definition of flux density and its unit—"Lumen—the unit of luminous flux, equal to the flux emitted in a unit solid angle (steradian) by a point source of one candle power." To this is added a footnote, "A uniform source of one candle emits 4π lumens." The definitions, which are quite unintelligible to a layman who has not given some consideration to the concepts of flux and solid angle (the term "steradian" is practically unknown in Great Britain), contain dimensions which are not logically necessary and which give rise to the complication. The lumen, originally introduced by Prof. Blondel, is a very important unit, but it should be a derived one, just as a unit of volume is derived from the unit of length. In dealing with light, as with magnetism, we cannot avoid 4π and the solid angle. One course is to embody 4π in a unit, the other is to wait until we meet it, and a good deal can be done in photometry aud illumination before this necessity arises.

The introduction of a solid angle and an intercepting area is as tautological as speaking of a horse-power-hour per hour. Assuming that a mental picture of the unit solid angle is formed with a candle at the apex, these definitions further demand the conception of an area of one square foot equidistant at all points from the apex, forming part of a sphere; otherwise the illumination would not be uniform The simple foot-candle definition demands only the mental picture of a candle and a small surface facing it, which, if fairly small, say the size of a penny, may be flat, for the illumination at the edge of such a disc received from a theoretical point source will be 0.996 of the illumination at the centre, that is to say, practically uniform. This conception of the unit of illumination makes the economy of thought.

It is highly satisfactory that the "candle," a definite physical quantity measurable to a fraction of one per cent., has been agreed upon by the authorities in the United States, France, and Great Britain, but so long as the Hefner unit is also regarded as a unit of intensity of illumination it is not wise to use the terms lumen and and lux without qualifying them as candle-lumen, Hefner-lux, etc.

The meter-candle will naturally be used in countries where the metric system is in common use, but since a metre is so nearly equal to the square root of 10 feet, one foot-candle is equivalent to 10.76 metre-candles, or for most practical purposes to 10 metre candles.

The effort to think of a lumen per square meter of the surface of a sphere of one meter radius is reduced by the proposal of a unit to be named "Phot" where the illumination is one lumen per square centimetre. This would be very high illumination and the "milliphot," or one-thousandth of a lumen per square centimetre, is of a practical magnitude, 1.076 milliphots being equal to one foot-candle. It does not seem likely that this will "catch on" in this country.

The name "*exposure*" is suggested in the U. S. report for the product of illumination by time. Prof. Blondel has proposed the name "photsecond" for the unit. The "bougie-metre-second" was adopted at the International Photographic Congress at Brussels in 1891, but little has been heard of it. Useful as it might be for photography, it seems a pity to give it a name with so narrow an implication. It might be called "quantity of illumination." Prof. Blondel recommended, some years ago, the "lumen-hour" as a unit on which commercial contracts for lighting should be based.

The next term on the list is *Brightness*. This word is used in two senses, emissive brightness of a source of light, and reflective brightness of an illuminated surface. The U. S. definitions relate apparently only to the former. "*Brightness of an element of a luminous surface from a given position* is the luminous intensity per unit area of the surface projected on a plane perpendicular to the line of sight, and including only a surface of dimensions neglibly small in comparison with the distance of the observer. It is measured in candles per square centimetre of the projected area." "*Normal brightness of an element of a surface* (sometimes called *specific luminous intensity*) is the ratio of the luminous intensity of the element taken normally to the surface of the element. and is expressed in candles per square centimetre." Perhaps this refers to secondary brightness of a diffusive reflector. If so, there seems to be no need for restricting it to the normal direction. Such reflectors are very useful in other directions.

The pith of these two definitions is that brightness is to be expressed in candles per square centimetre. The rest, and the equations which are given in the report, explain how the definitions are applied. Emissive brightness, when not expressed in candles per square inch, has hitherto been given in candles per square millimetre; the brightness of the crater of a carbon arc is about 160, and of a candle flame about 0.39 candle per-sq. mm. This quantity is *éclat intrinsèque* in French, or *primäre Helligkeit* (P. H.) or merely *Helligkeit* in German. We have a similar word "brilliance," but, like the French word *clarté*, it is not used as a scientific term. We have another word, "luminosity," but that has been used by Abney and others in connection with the spectrum.

Brightness has another and very important meaning for which the term "surface brightness" or "secondary brightness" is sometimes used; the German equivalent is "*flächenhelle*," or "*sekundäre Helligkeit*" (S.H.). A perfectly white unpolished surface of an area of π square feet receiving an illumination of 2 foot candle bocomes a secondary sonrce of illumination equivalent to 1 candle normally, and has a hemispherical candle power of $\frac{1}{2}$ candle, but this reflective brightness is generally expressed and measured in a different way.

It is of great practical importance that "surface brightness" should be recognized as a definite and accurately measurable physical magnitude, whatever name is given to it. It is a compound quantity consisting of two factors, illumination and the coefficient of diffused reflection. Several practical instruments with which industrial photometry is carried out depend entirely upon the measurement of brightness. Sometimes the object is not to measure brightness, but to measure illumination. For this purpose a piece of white card or unpolished celluloid is used. When this receives an illumination of one-foot candle and is observed through the instrument, the brightness is found to be eqnal to the brightness of a screen contained in the instrument when one-foot candle is indicated on the scale. The instrument being calibrated by experiment, measurements of illumination may be made with it.

But this unit reading does not correspond with the true unit brightness. The card or celluloid reflects only about 80 per cent. of the light incident on it, in other words, its coefficient of diffused reflection is about 0.8, or its albedo is 0.8. If this is measured, the coefficient of diffused reflection of other surfaces receiving the same illumination may be directly compared. A knowledge of this coefficient for different colored paint, distemper. or wall paper is of great practical importance. This coefficient is the next term defined.

Coefficient of Reflection.—"The ratio of the total luminous flux reflected by a surface to the total luminous flux incident upon it. It is a simple numeric. The reflection from a surface may be regular, diffused or mixed. In perfect regular reflection all of the flux is reflected from the surface at an angle of reflection equal to the angle of incidence. In perfect diffused reflection the flux is reflected from the surface in all directions, in accordance with Lambert's cosine law. In most practical cases there is a supposition of regular and diffused reflection." This is an excellent statement of the matter. It is analogous to transparency which is regular or to translucency which is diffused. In measuring regular transparency, such as that of neutral tinted glass, it is sufficient to place a specimen in the path of a beam of light and to observe the effect upon the apparent candle power of the source. But attempts to measure the absorption of ground glass or opal glass in this way have often led to the publication of erroneous results. The light scattered over a hemisphere must be taken into consideration, samples must be measured at different angles, and the whole sum must be calculated. In doing this, by any of the well-known methods, such as that of Kennelly or Russell's modification of Rousseau's curve, the flux over 2π is implicit, but we deal with candle-power all the time. Dr. W. B. Sumpner, in his measurements of diffused reflection and transmission, worked with the flux, with the result that his paper can only be read by those who have a good working acquaintance with integral calculus.

Since surface brightness consists of the two factors, illumination and the coefficient of reflection, and since brightness can be accurately compared and illumination can be accurately measured, this coefficient may be deducted without measuring flux as such, and without introducing the lumen into the work.

It is desirable that a distinction should be observed between the coefficient of diffused reflection of a substance and the summation factor of repeated reflection. In both cases it is desirable that the true coefficient or factor be used, and not the arbitrary one which assumes that a certain card is perfectly white. In predetermining the result of a case of indirect lighting where the lamps are hidden and where a cove or ceiling becomes a secondary, and the only source of light, its value in a direction normal to the surface is its true brightness divided by π. The U. S. Report contains a number of terms such as *Primary luminous standard, Reference standard, Working lamp*, and others which have fairly self-evident meanings.

Mean horizontal candle-power of a lamp is defined as "the average candle-power in the horizontal plane passing through the luminous center of the lamp. It is assumed here that the lamp (or other light source) is mounted in the usual manner, or, as in the case of an incandescent lamp, with its axis of symmetry vertical.'

Mean spherical candle-power of a lamp—the average candle-power of a lamp in all directions in space. It is equal to the total luminous flux of the lamp in lumens divided by 4π."

"*Mean Hemispherical candle-power* of a lamp (upper or lower)—the average candle power of a lamp in the hemisphere considered. It is equal to the luminous flux emitted by the lamp in that hemisphere divided by 2π."

These three definitions are of great practical importance, and being practical the corollary about flux, for it is nothing but corollary, might have been omitted.

In the case of all gas mantles and electric glow lamps, except perhaps those with a conical arrangement of filaments, the mean horizontal candle-power is a definite term and the one which will naturally be used by manufacturers in testing and marking, since it is generally the maximum. It would be difficult to induce them to use the mean spherical candle-power as an ordinary description, even if any good reason could be found for asking them to do so. The present fashion of rating electric glow lamps in watts is a step in this direction, for the watts mean nothing to the layman, but if you give him the watts per candle you must give him horizontal or mean spherical candles.

In the case of arc lamps the mean horrizontal candle-power is practically useless, and the choice lies between spherical and hemispherical; for the maximum candle-power which used to be given in a plain, commonsense way, is not likely to be revived. It is not much use for theoretical men to dictate to arc lamp makers how they shall describe their goods. All that can be done is to settle the definitions and to invite them to agree upon some common usage.

It is somewhat characteristic of the U. S. report that it defines the "spherical reduction factor of a lamp" as "the ratio of the mean spherical to the mean horizantal candle-power of the lamp," and sends the reader to a footnote, which informs him that in the case of a uniform point source this factor would be unity, which is fairly obvious, and for a straight cylindrical filament obeying the cosine law it would be $\pi/4$, leaving him to work out the value .785398 to as many places as he likes on his shirt-cuff.

Symbols. It is generally assumed that there is an intimate connection between nomenclature or the drafting of definitions, and the symbols which are used to represent the terms and quantities, but there is no connection. To define a term clearly, completely and concisely, is a matter of comprehension of the meaning, and of logical expression. To propose a symbol needs but a superficial acquaintance with the term to which it is to be applied, and logic interferes rather than helps, for general rules in symbology always fail as soon as they are propounded. The best way to start on the question of symbols is to have a good acquaintance with the usage of the leading writers who employ them, for some use few or none. By almost universal consent, candle-power or luminous intensity is represented by I, except by Germans, who do their best with J. The use of *cp* or *c.p.* is impossible in a mathematical expression, but it is useful as a contraction, though it is purely English.

The symbol I θ, the θ being used to distinguish it from a zero, has been suggested by Continental writers for mean spherical candle power. I ⏑ for mean hemispherical candle power in the lower hemisphere, and I ⏠ for the upper hemisphere. The English contractions, MSCP, MHSCP, are very useful, though they cannot be used in mathematical work. The symbol I_h has been suggested for mean horizontal candle power, and J-K or HK for a Hefnerkerze, but it is hoped that the distinction between this and the candle power will soon disappear.

The symbol for illumination adopted by many writers is E. A difference of opinion arises about flux. The small Greek ϕ has been suggested by the Verband deutscher Elektrotechniker and the Verein von Gas und Wasserfachmännern, but the International Electrotechnical Commission in their provisional rules recommend that small Greek letters should be reversed for angles. Of such letters, ϕ, θ, and ω are frequently employed for that purpose, and the I.E.C. propose the capital Φ for magnetic flux, with the alternative of script or sanscrif or clarendon F. The U. S. Report suggests an ordinary F or $\mathcal{F}$, and further propose that in order to avoid possibility of confusion with electrical symbols, that symbols for photometrical quantities should be derived exclusively from the Greek alphabet, allocating $\mathcal{I}$ for luminous intensity and B for illumination. The I.E.C. adopt the italic *I* for electric current, it being customary to print mathemattcs in italics. The B for illumination is a bad choice, for there is no difference between the Greek and the Roman letter.

The nomenclature of the chief photometrical terms is ripe for settlement. Every foreigner who can read English should know what we mean by the word illumination, and every English-speaking man who can read French and German should know what is meant by éclairment and Beleuchtung. It is first necessary that these terms should have a well-defined meaning and that this should meet with general acceptance. This is one branch of science in which originality is not wanted; the word coiner is too often a crank and a nuisance. Photometry and illuminating engineering have not sprung suddenly on the world like wireless signalling and flying. In such work the inventors must produce words to describe their discoverics and inventions. But we have a literature of a hundred years behind us. It should be our object to record what appears to be the general usage of the day rather than to guide the scientific literature of the future. In this paper the intention has been to make for lucidity and simplicity, without loss of accuracy, and thus to render the literature of the subject intelligible to a wider section of the public.

Dyestuff Manufacture in America.

[By J. M. Matthews, in *Daily Trade Record.*]

As is known, the large majority of the dyes at present employed in this country are manufactured in Germany. There has been considerable mention made of the establishment of the dyestuff industry in this country owing to the fact that we have available large quantities of raw material. As nearly all the dyes are made from coal tar, and as coal tar is derived from the distillation of coal for the production of illuminating gas, it would be the impression off-hand that we could quickly ourselves utilize our coal tar products.

A little careful consideration of this question, however, causes us to somewhat revise our first judgment in the matter; considerable difficulties confront us although they can all be overcome.

While it is true that this country produces large quantities of coal tar, it is also true that we are not very large producers of benzol, and its consumers which form the real basis of the dyestuff substances. Benzol is a liquid of rather low boiling point and consequently of a volatile character, sometimes called benzene, but which is not to be confunded with petroleum, naphtha or benzene, the latter being a very different chemical substance. Benzol is obtained by the distillation of coal tar which itself is produced by destructive distillation of coal in retorts. When bituminous coal is heated in a closed retort, large quantities of gaseous products are evolved, together with a considerable amount of a dark peculiarly smelling liquid, while there is left behind in the retort a solid residue known as coke. The gas and the liquid distillates are separated from each other by scrubbing and washing, and the gas is used for illuminating gas. The liquid coal tar can be subjected to further distillations between varying ranges of temperature, and in this manner there is obtained a series of distillates running from the first light oil distillate to the heavy oils, and a black substance is left undistilled, known as pitch.

The character of the coal employed and the method of conducting its distillation cause wide variation in the quantity and nature of the constituents present in coal tar. The coal tar obtained by present American methods of distillation is capable of yielding but a very small quantity of benzol and anthracene, two of the principal raw materials used as a starting point in the manufacture of coal tar dyes. We will have to change our system of producing illuminating gas so as to leave the proper kind of tar. This will eventually permit a greater profit even to the gas maker, besides giving the dyestuff maker the ingredients which he needs. While our coal tar does not yield much benzol and anthracene, it does yield a large quantity of naphthalene, a substance which is familiar to most people under the form of tar camphor or moth balls, and naphthalene can be employed for the production of indigo and a few other dyestuffs but it does not find any very extensive use outside of the indigo colors.

There are in this country several establishments where some coal tar dyestuffs are produced, but nearly all of these depend on Europe for most of their raw materials and intermediate products, and should these supplies be cut off, they would be in a very poor condition to supply even to a small extent the requirements of the textile trade.

It is fortunate that logwood is largely manufactured in this country, and there is no doubt that sufficient logwood dyestuff could be

produced by our domestic factories to meet all demands. This dye is extensively used for the dyeing of black silk and in some degree for black cotton and wool. It is also possible that a considerable quantity of analine salt can be produced here which would take care of a good portion of our aniline black dyeing on cotton piece goods and hosiery; but for the great majority of colors, especially the fast colors for wool and cotton, the present outlook is not by any means promising. We will have to develop a dyestuff industry of our own.

The most important dyestuff is indigo, for without doubt this single dyestuff is employed in larger quantity than any other. At the present time a very large quantity of our supply of indigo is made in Germany from coal tar, this product having, to a large degree, displaced the natural indigo formerly obtained by extraction from the indigo plant. The indigo made from coal tar is identical with that from the plant and is in a much higher state of purity. It is also brought into trade in a form which is more readily adapted to the dyeing process. The natural indigo was usually sold to the buyer in the form of rather large blocks or lumps, and it had to be ground in special mills in order to reduce it to a very fine state of division, as only in this form can it be employed in the preparation of the dye vat. The indigo prepared from coal tar and known as synthetic indigo, in the process of its manufacture is obtained in a very fine state of division, and this is made up in the form of a paste so as to prevent the formation of lumps and is available to the dyer in this form. We have in this country large quantities of naphthalene available for the production of indigo, but foreign patents would stand in the way of our making this color economically. We will have to revise our patent laws, compelling foreign patentees to produce in this country. Further, we must develop our own methods of production. It is true that, no doubt, the suppression of the synthetic indigo making would simulate very largely the cultivation of natural indigo which chiefly comes from India and the East Indian islands, and it is probable that our supplies of indigo could be largely drawn from this source. During the last few years, however, the acreage of indigo under cultivation has been very widely reduced owing to the material decrease in price through competition with the synthetic indigo and it would take some time to readjust agricultural conditions in East Indian countries to very materially increase the production of vegetable indigo.

If necessity, growing out of a protracted war in Europe, demanded it, there is no doubt that our methods of distilling coal for the production of illuminating gas could be so modified as to form a coal tar suitable for the production of benzol and other intermediate products in the dyestuff industry.

Correspondence.

The JOURNAL is not responsible for the opinions expressed by correspondents.

The Lease of the Richmond, Va., Works.

RICHMOND, VA., August 18th, 1914.

AMERICAN GAS LIGHT JOURNAL, New York—Dear JOURNAL: We are surprised to read the concluding line to this paragraph in your August 10th issue:

"The Richmond (Va.) Council Committee on 'Public Buildings, Properties and Utilities,' has still before it the proposition of the Southern Gas and Electric Company to lease or purchase the municipal gas works, *but the matter will probably be dropped for all time.*"

The italics are mine, so given to call special attention to the remarkable conclusion your correspondent, probably a Richmond city official, or inspired by one, arrives at; for be it known that the gas works in Richmond has been a political factor during most of its wobbly career Your correspondent's wish is probably father to the thought: there will be no place for politics in the Richmond Municipal Gas Works when the Southern Gas and Electric Corporation shall have leased them, which is much nearer to-day than ever before. As a Councilman said to me this morning: "I cannot yet say it out loud, for the political effect, possibly; but the Southern Gas and Electric Corporation will have the gas works leased to it, because the city is tired of the City Hall political management, with all its bad service, time-serving and general unbusiness-like methods." If I read the signs of the times right, the thinking business citizenship of Richmond is about ready to have its property turned over to business managers who will give the city the service it has a right to demand, with the guaranteed returns on its public investment it ought to have, and an actual realization of extensive betterments to the property long promised but never made.

I think you will do our proposition the justice of giving to this the degree of publicity accorded the quoted item.

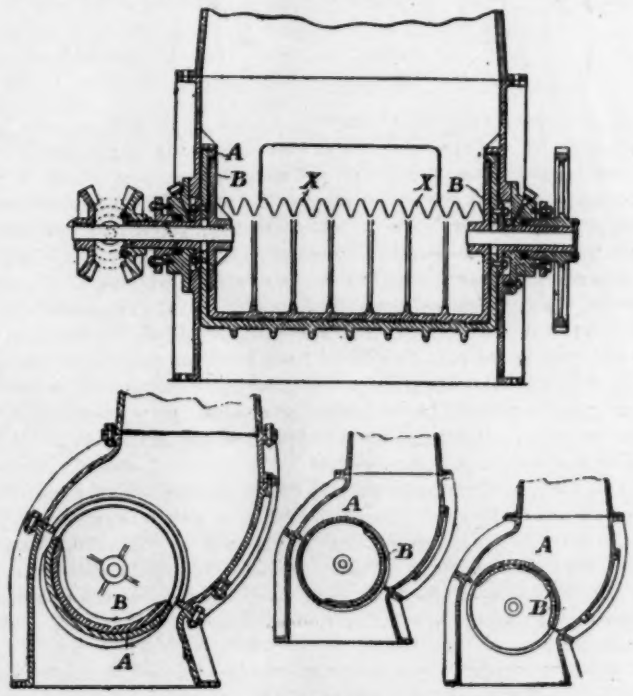
Very truly yours, L. I. POLLITT,
V. P. and G. M. Southern Gas and Electric Corporation.

New Methods and Appliances.

DISCHARGING VERTICAL RETORTS.—An English patent has been issued for the apparatus illustrated, called the Drake and Dobson Vertical Retort Discharger.

This mechanism is of such a character as will enable the discharging of any desired quantity of coke without the possibility of any larger quantity being permitted to descend by gravity. A further advantage secured is that "the coke extracted is not broken to the extent that it is necessary for its discharge by devices at present in use."

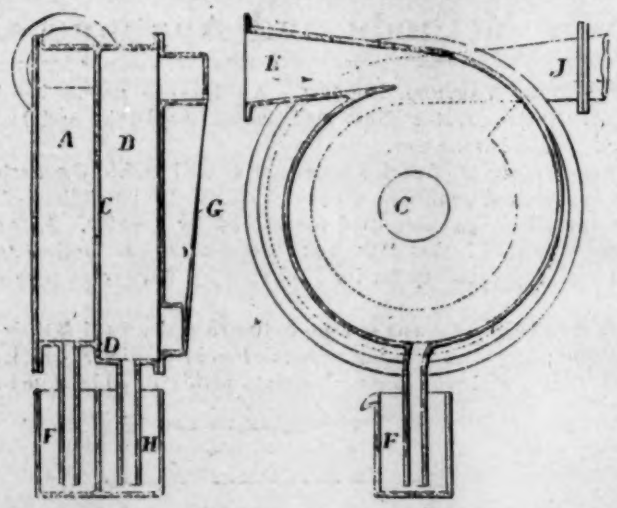
With each retort is a pair of semi-cylindrical drums *A B* their axes co-incident; the drum *B* being so much less in diameter and length than *A*, that it will take into and operate within it, and rotate in one



direction while the drum *B* is rotated in the other direction. As these pairs of drums are rotated, they will at one time present their open sides to the base of the retort, so that the material in it will descend by gravity and enter the drum *B*. By continuing the motions of the drums their opposite edges will commence to approach each other gradually, cutting their way through the material which now extends from the interior of the drums up into the retort. The rotary motion being continued after the edges of the drums have met, the portion of the material within is cut off from that above, and by the drums still moving forward their open sides are gradually brought face down to deposit their contents below. In order that the cutting edges may perform their functions by shearing actions, the prongs *X* may be of varying lengths; the longer prongs being made to extend beyond the edges of the drums, but having their inner surfaces flat, so that the distance between the points of the prongs on opposite sides of the drum equals, or is larger than, the inner diameter of the drum. The longest prongs may be about midway the length of the two drums; the remaining prongs gradually diminishing in length towards the right and left, where are the shorter prongs, or the longest prongs may be at one end of the drums; the remaining prongs gradually diminishing in length towards the other end.

CENTIFUGAL TAR EXTRACTOR.—M. Mazeron before the Société Technique, described this "new" tar extractor. To effect complete separation tar and gas the weight of the tar particles must be increased, or they may be subjected to the action of centifugal force, either by the

gas being given a rotary movement by means of a fan, or by being projected against the inner surface of a cylindrical vessel by a suit able fall of pressure—the principle of the "Cyclone" appliances. If, however, the gas and the tar fog are subjected to centrifugal force alone, separation is not complete, owing to the tenuity of the tarry particles, which prevents their sufficiently rapid displacement. This has led to a increase preliminary of the size of the particles; and with the view of effecting it this appliance has been devised.



The apparatus consists of two chambers *A*, *B*, side by side, communicating by an opening *C* in the centre of the partition *D*. The gas reaches the inner surface of the chamber *A*, into which it is injected by a conical shaped adjutage *E*, at high tangential speed, which gives it a whirling movement; and the gas converges towards the centre in order to pass by the opening *C* into the second chamber. The separated tar is collected in a receptacle *F*, forming a trap at the bottom of the apparatus. In the second chamber the gas passes from the centre to the circumference, and the tangential speed is reduced and changed into pressure. The exit of the gas from this chamber is by a volute *G*, of rather smaller radius than that of the chamber. In this way the separated tar is projected against the inner surface, and flows away by the trap *H*, while the cleaned gas goes out by the pipe *J*. The reduction in the size of the tarry particles is effected in the first chamber, and their separation in the second. The pressure absorbed by the apparatus is only 24-10ths for an average output, notwithstanding the high speed nearly 500 feet per second attained by the gas towards the centre of the vessels. The appliance requires no attention and is best placed on the discharge side of the exhauster; and, owing to the return regulator, the volume of gas passing through it is constant.

Recent Patent Issues.

Prepared for the American Gas Light Journal by Royal E. Burnham, solicitor of patents and counselor in patent causes, 833 Bond Building, Washington, D. C., from whom illustrations and specifications of any patent mentioned below may be obtained for 20 cents.

1,105,578. Process of Purifying Gas. C. J. O'Donnell and A. F. Kunberger, Philadelphia, Pa., assignors to The United Gas Improvement Co., same place.

1,105,581. Registering Meter for Gas and the Like. J. M. Rusby, Philadelphia, Pa., assignor to The United Gas Improvement Co., same place.

1,195,582. Clamp for Vertical Retort Doors. J. H. Taussig, Philadelphia, Pa., assignor to The United Gas Improvement Co., same place.

1,105,663. Gas Lighter. G. W. Hosler, Findlay, O.

1,105,688. Gas Producer. T. H. Paffrath, Butler, Pa., assignor to J. W. Carnahan, Washington, D. C., and A. P. Starr, Butler, Pa., trustees.

1,105,772. Process of Making Gas from Oil. W. A. Hall, New York City.

1,105,780. Gas Burner. J. W. Higgins, Jackson, O.

1,105,841. Gas Regulator. J. R. Ricketts and H. V. Leahy, Los Angeles, Cal., assignor to Perfection Gas Regulator Co., same place.

1,105,868. Extractor of Liquids and Solids from Gases. J. T. Wilkin, Connersville, Ind., assignor to The Connersville Blower Co., same place.

1,106,319. Process of Controlling Combustion. J. M. Rusby, Philadelphia, Pa., assignor to The United Gas Improvement Co., same place.

Items of Interest
FROM VARIOUS LOCALITIES.

General Manager Crawford, of the Clinton (Ia.) Gas and Electric Company, is receiving congratulations on the completion of the additions to his plants. The improvements at the gas works included raising the generator house roof, installing a million-foot water gas set, and building a 15-foot purifier.

These two charters have been granted in Delaware, both to J. M. Satterfield, W. P. Carrow and M. M. Hirons, of Dover: The Nebraska Gas and Electric Company, with a capital of $1,000,000; and the Iowa Gas and Electric Company, with a capital of $500,000.

Mr. Edward Merrick, Manager of the Newtown (N. Y.) Gas Company, in Queens, died recently from heart disease in Derry, N. H., where he was summering with his family. News of his death was sent to his friends in Flushing, where he has lived for 15 years. He was twice married, his first wife being a sister to Dr. Melville R. Chapman, of Flushing, and of Elberton S. Chapman, banker and broker. His second wife, who survives him, was Miss Susan Davies. He also leaves three sons by his first wife.

The removal of the large Laclede Gas Light Company main, which blocked the progress of the building of the Tower Grove Viaduct, in St. Louis, Mo., has been started. The question of its removal has been in dispute for months. The Missouri Pacific and the Frisco Railroads are building the viaduct, and all the other public utility corporations affected have removed their properties that were obstructive, but a controversy arose between the railroads and the officials of the Laclede Company as to who should bear the cost of the removal of the main. The Laclede Company also is desirous of obtaining several permits for erecting poles and stringing wires to supply electric service, and a recent opinion of City Counsellor Baird holds that under its charter it can sell only gas. This led to a conference at which it was suggested that the Laclede Company agree to remove its main under protest. The citizens of St. Louis are not interested in who shall pay the cost of the removal of this obstructing main, but they are vitally interested in having the viaduct completed. The question of sharing the cost can be fought out in court after it is removed.

Improved gas service for Sag Harbor, Southhampton, Bridgehampton and Easthampton, Long Island, N. Y., is assured by an order of the up-State Public Service Commission, permitting the Long Island Gas Corporation to purchase the works, system, franchises and properties of the Sag Harbor Lighting Company, gas franchises of Harry F. Cook in the town and village of Southamptsn, and to issue securities to make extensions and improvements throughout the territory. An issue of $200,000 of the 5 per cent. 25-year first mortgage bonds, $75,000 common, and $25,000 preferred stock of the Long Island Gas Corporation is authorized. $85,000 of the bonds must be sold for not less than $73,000, with which the Sag Harbor property will be purchased. The rest of the bonds must not be sold at less than 85, and the stock at not less than par. With this sum high pressure trunk lines and equipment will be installed from Sag Harbor to Southhampton and from Bridgehampton to Easthampton. Distribution lines will be installed in these communities and improvements to generators and existing lines throughout the territory will be made.

The City of Woodbury, Gloucester County, N. J., has obtained from Supreme Court Justice Garrison an order requiring Mayor Millard F. Cattell to show cause on September 17, why a peremptory or alternative writ of mandamus should not issue against him to compel him to execute two contracts for lighting the streets of the city for the ensuing 5 years from July 1. One of the contracts is with the Public Service Electric Company and the other with the Public Service Gas Company.

The work of repairing a high pressure gas main under East River, at Green Bay, Wis., is being completed by a diver in the employ of the Wisconsin Public Service Company. The standard amount of gas will be supplied to North side users when this work is finished. The main was broken when Greiling Bros. Company was engaged in driving piling for the St. Paul railway bridge, which will connect the extensions on either side of the stream.

COUNCILMAN T. W. WOOD, Wilmington, Del., expects to bring before the City Council a proposition for a municipal gas lighting plant. He proposes to have the city purchase the existing plant of the Tidewater Power Company, if it can be had for a reasonable price, and if this is not possible to build an entirely new plant. Mr. Wood's idea is that the city, by owning its public utilities, can not only furnish service to the patrons at a lower rate, but also may have whatever profits accrue to be used in public work. He stated that in Atlanta there is a gas plant, owned by a corporation which has made a net profit of $400,000 on a gross income of $800,000. Other cities are making money from their plants, he declared, and are charging a lower rate than the consumer has to pay in Wilmington. He expressed it as his opinion that it really was of more importance to Wilmington that she should own her gas plant than her electric light plant, though he is in favor of having both plants placed under municipal ownership.

IN Palatka (Fla.) the people are discussing light, heat and power, and there is talk concerning the proposed changes in the company which furnishes electricity and gas—and discussion about the possibility and advisability of publicly owned utilities. An application for an extended franchise is before the City Council, the present owners of the gas and electric company's plant being likely to sell out to a new concern and the matter will likely be submitted to the people. That municipally owned utilities have proved successful and remunerative in other places is urged by those favoring a city plant, and there are also many Palatkans who do not approve of the idea. In any event the changes that will be made shortly will be for the benefit of citizens generally, for the new company proposes to have a twenty-four hour service and greatly increased capacity.

"S. G.," WRITING from Windsor-Locks, Conn., says: "The mills have been shut down during the week and the water in the canal drawn off. The Northern Connecticut Light and Power Company has been connecting up the gas mains with the holder that was placed at the power station on the canal bank a few weeks ago, to be used as a supply, when the pressure gets low during the day. It was necessary to run a pipe from Main street across the canal to the tank, and this could be done only when the water was out of the canal. The company expects that the tank will enable them to give better gas service in the future. Lately the pressure has been very irregular as in some parts of the day the demand is so heavy, as to exceed the supply. It is intended to pump the tank full of gas during the night when the demand by the consumers is lowest, and then admit it to the mains during the day as required.

THE Attleboro (Mass.) Gas Light Corporation has purchased 18 acres of land opposite the Mossberg factory in Attleboro and plans the erection of a new plant. The property extends from John William street and Thacher street to the railroad and the Ten Mile river. A spur track will be built to the property. The present plant of the Company is outgrown. When an attempt to locate the new site nearer the centre of the town, brought a protest from near-by property owners, the company considered the alternative proposition of buying gas in Rhode Island and bringing it to Attleboro by a pipe system. The purchase announced is evidence of its decision to build a new plant instead.

THE Gas Machinery Company has just completed the installation of a 11′ set for the American Light and Traction Company's St. Paul, Minn., plant, and is at present installing an 11′ set at their San Antonio, Texas, plant.

THE City Council of Los Angelas, Cal., has adopted the ordinance submitted by City Attorney Stephens and eliminating the maximum percentage of natural gas that must be mixed with artificial gas in the event that a mixed gas is supplied by the companies. In serving a mixed gas the companies will not be permitted to mix less than 50 per cent. natural gas with the artificial gas.

MR. EDGAR Z. WALLOWER, Superintendent of the Harrisburg Light and Power Company, has been made General Manager of the Lockport Light, Heat and Power Company, Lockport, N. Y., and will assume full charge of the company's electric, steam and gas plants on September 1.

UNITED STATES District Judge Hollister, at Cincinnati, O., has handed down his opinion upon the petition for review of stockholders of the Hamilton Gas and Electric Company, seeking a reversal of an order of Referee Haines, levying an assessment of 100 per cent. upon $300,000 worth of bonus stock issued by the company in 1907. The order of the referee is sustained for the most part and the Court holds that all creditors whose debts were created after the bonus stock was issued, except those creditors who are holders of bonus stock or who had knowledge of its issuance prior to the date of the creation of their debt, are entitled to share in the fund arising as a result of the assessment. He also holds that the Trustee in Bankruptcy of the Hamilton Gas and Electric Company may bring a suit to recover. The entire matter is referred back to the referee, with instructions to ascertain which of the creditors hold claims contracted prior to the issue of the bonus stock and to report his conclusions of fact and law in such a way that the Court may either sustain or overrule his findings.

THE contract for the three new purifying boxes at the Richmond, Va., Municipal plant has been awarded to the Stacey Manufacturing Company of Cincinnati. The price was about $16,000.

MR. M. K. BURGNER, of Chambersburg, Pa., is to succeed C. G. Goeltz as Superintendent of the Chambersburg Gas Company. Mr. Burgner has heretofore been Superintendent of Highways for Franklin and Fulton Counties, Pa.

AT a meeting of the City Council of Auburn, Wash., a franchise was granted to the Auburn Gas Company, represented by J. L. Veach, and as soon as possible this company will install a modern gas plant at a cost of between $40,000 and $60,000. The plant will be capable of furnishing the entire town with coal gas for commercial, fuel and illuminating purposes at a price of $1.40 per thousand cubic feet.

OREGON CITY, ORE., reports the granting of a franchise to the Clackamas County Gas Company, by the County Court, giving that concern the right to lay mains on the Whitehouse road to Oswego, which is a part of the plan of the Company to avoid Milwaukee in its line to Oregon City from Portland. Owing to the fact that the Company and the Milwaukee council were unable to come to any agreement on the franchise through that town, the gas company has reached the determination to go around the town. By crossing the river below Milwaukee, touching Oswego, and then recrossing above Milwaukee, that town is avoided and Oswego added to the territory covered. The main from Portland to Oregon City is practically completed with the exception of the gap at Milwaukee.

ENGINEER H. L. St. John reports the work on the Corpus Christi (Tex.) Gas Company plant proceeding satisfactorily. The gas holder is nearly completed, the iron in the crown now being placed; the foundation for the plant structures are in place, and a good mileage of mains is already in the ground. It is expected to deliver gas by September 26, the time limit on the franchise.

OHIO utility companies that suffered from the floods of last year are making reports of the damages done them. The Dayton Gas Company in the last report filed with the State Public Utilities Commission, gives $9,932 as expended during the three months ending June 30, for repairs made necessary by the flood.

IMPROVEMENTS which call for an expenditure of from $12,000 to $15,000 are under way at the gas plant of the Muscatine (Ia.) Lighting Company. A new permanent structure, 30 by 75 feet, is to be erected to house several additional boilers as well as a water gas machine. The improvements are expected to take some time as demolition of a portion of the present plant is necessary.

IN connection with its reduction to 80 cent gas, the East Boston (Mass.) Gas Compony announces these prices for lamp maintenance and rental:

Inside Arcs, rental....	25c. per mo.	Maintenanace....	25c.
Outside Arcs, "	25c. "	"	35c.
Reflexoliers "	25c. "		
Single burners.....			10c.

This includes two inspections per month, replacing mantles and ordinary glass ware, also cleaning and adjusting burners. The reduction, as noted, brings gas as a commodity within the reach of everyone, making it possible for housewives to reduce household expenses to conserve their energies, through the medium of modern gas appliances, thereby improving the standard of efficiency in the home and tending to the betterment of the general welfare of the community.

Utilities Commission News.

MARYLAND APPOINTMENT.—Governor Goldsborough, of Maryland, has announced the appointment of former Judge W. L. Henry, of Dorchester County, as a member of the Maryland Public Service Commission, succeeding Hon. Philip D. Laird, former chairman of the board, who resigned. The new commissioner, who is a Democrat, will take office at once and will serve about eighteon months to complete Chairman Laird's unexpired term. Judge Henry is a resident of Cambridge and is fifty years of age. Commissioner Alberg G. Towers has been designated as chairman of the commission.

NOT ALLOWED TO PURCHASE.—The application of the Phoenix Gas and Electric Company, of Phoenix, Oswego County, N. Y., for permission to purchase a gas franchise has been denied by the Public Service Commission, and will, therefore, have to apply again for approval of a contract for the sale of electric franchises and property made at the same time. The application was vigorously opposed by the Seneca River Power Company, already serving much of the territory.

CONFER ON GAS PROBLEMS.—Engineer Russell, of the Maryland Public Service Commission, has been in Washington for a conference with E. G. Runyan, inspector of gas meters, and Benjamin A. Harlan, chief clerk of the public utilities commission of the District, in regard to new gas regulations in the two cities. Several features of the new regulations promulgated recently by the District commission have been tried in Baltimore for four years with gratifying success, Mr. Russell reported. Other features of the new District requirements are to be embodied in regulations soon to be promulgated by the Maryland commission. The public utilities law of the District was largely modeled after the Maryland law. New regulations governing the extension of gas mains and the cost and ownership of gas service pipes are to be considered at a hearing to be held by the utilities commission in the boardroom at the Municipal building, Friday morning, at 10 o'clock.

BONDS FOR EXTENSIONS.—The Public Service Commission of Indiana recently granted the Citizens Gas Company of Indianapolis authority to issue bonds in the sum of $25,000, the proceeds to be used in making approximately 22,000 feet of extension ordered by the Board of Public Works. The bonds will pay interest at the rate of 5½ per cent. and will run for 5 years. The petition for permission to issue bonds was filed with the Commission July 30. The funds derived from the issus will be used exclusively to build extensions.

EARNINGS OF UTILITIES.—Public service corporations operating in Rhode Island made total gross earnings in the last fiscal year of $19,918,117,74., according to the report of the State Tax Commission. The tax upon the corporations, at rates of from 1 to 3 per cent. on gross earnings, amounted to $220,992.07, an increase of $7,000 over the previous year. The earnings by classes of service were as follows: Express corporations, $77,769.01; steamboat and ferryboat corporations, $551,722; steam and electric railroad, $6,111,380.94; street railways, $5,645,424.66; dining, sleeping, chair and parlor car corporations, $111,568.57; telegraph, cable and telephone corporations, $2,025,574,92; gas, water and electric lighting, heating and power corporations, $5,394,677.64. The largest earnings are reported by the New York, New Haven & Hartford Railroad, with a total of $6,047,834.02, while the Rhode Island Company, an electric railway corporation, stands second, with earnings of $5,358,528.58. Other large earnings are: Providence Telephone Company, $1.683,720.26; Narragansett Electric Lighting Company, $1,480,237.77; Providence Gas Company, $1,610,124, and Blackstone Valley Gas and Electric Company, $922,458.72.

CALIFORNIA FRANCHISES.—S. Waldo Coleman has obtained a certificate of public convenience and necessity authorizing the construction and operation of a gas distributing and manufacturing system in Contra Costa County. Franchises have been granted him by the cities of Antioch, Martinez, Pittsburg and Concord.

REDUCES GAS RATE.—Reduced gas rates for the city of Taft have been ordered by the California commission, after investigating complaints of citizens against the West Side Gas Co. The new schedule includes a rate of 70 cents per 1,000 cubic feet for the first 5,000 cubic feet per month, with a minimum monthly bill of $1. The new rates were ordered into effect within 30 days.

Financial Notes.

FIVE operating subsidiaries of American Gas and Electric Company reporting for the twelve monthe ended June 30, 1914, show good gains in gross, net and surplus. These companies are well distributed, operating in Ohio, Indiana, Illinois, Pennsylvania and West Virginia. Their combined gross was $2,608,723, a gain of 19.22 per cent. over the preceding year. The combined net was $1,400,354, a gain of 21.03 per cent., while combined surplus was $907,238, an increase of $159,053, or 21.25 per cent. American Gas and Electric controls eleven operating subsidiaries, combined gross of which for the twelve months ended April 30, 1914, was $4,006,353, so that the earnings of the five companies now reporting is well over half the total gross of the subsidiaries. With an increase of more than 21 per cent. in the combined surplus of these companies for the twelve months period American Gas and Electric should show good gains in earnings for its stocks in the current year, over 1913, even with the additional fixed charges by reason of the issue of the new 6 per cent. debentures. July 1 the company paid an extra dividend of 2 per cent. in common stock on its common and while it is not probable that an another extra dividend in common stock will be paid this year, it is quite probable that another may be paid early in 1915.

THE Cities Service Company defers dividends. The following announcement has been made by the directors of the Cities Service Company: "While hopeful that a general European war will not take place, that the acute conditions which now prevail in all the financial centers of the world will grow no worse, and that normal conditions will soon be established, the directors feel that every precaution should be taken to protect the interests of the company in event the worst should happen. The Board has decided, therefore, to defer payment of dividends, including those due Aug. 1, on the preferred and common stock of the Cities Service Company, to the end that the best interests of the corporation and its stockholders may be protected during this period of world-wide financial cataclysm." In a letter to the stockholders the directors said in part that "unless a decided change for the better occurs, it may be some time before normal financial conditions will prevail, and all requirements of the company may have to be met from the net earnings of the subsidiary companies. The earnings of these companies are entirely satisfactory, and we expect them to so continue. Your directors feel that all cash resources of the company should be conserved. They hope for an immediate change for the better which will insure a speedy return to normal conditions and enable cash dividends to be resumed. In their decision they are also mindful of the present practically prohibitive rate of exchange applying at this moment to dividend payments abroad."

THE Pacific Gas and Electric Co., announces that $8,750,000 of the $12,500,000 new preferred stock, which was first offered on June 3, had been subscribed for by 3,000 persons. As more than 70 per cent. of the issue has been taken up, the financial plan recently outlined to shareholders was declared operative. The distribution has practically doubled the company's stockowners. Because of the distributed conditions of international finances, payment of the second installment of $15 a share has been postponed from Aug. 15 to Oct. 15, and the third payment of $12,50 a share has been put back from Oct. 1 to Nov. 15. The final installment will be due on Jan. 15, instead of Jan. 1.

THE Consolidated Gas, Electric Light and Power Co., of Baltimore, has increased its quarterly dividend on its common stock from 1¼ per cent. to 1½ per cent. payable Oct. 1, to stock of record of September 19. The board also has authorized the exchange of the common stock, share for share for the outstanding $5,138,654 six per cent. preferred stock and all preferred stock exchanged previous to September 19, will receive common stock carrying the quarterly dividend at the higher rate. The retirement of the preferred stock is for the purpose of enabling the company to make the debentures of the company a general lien on all its property which it cannot do so long as any of the preferred stock is outstanding.

TRANSFER of the Chillicothe Electric Street Railway, Light and Power Company to the American Gas and Electric Company has been consummated. As a result of this acquirement by the American Company, it is expected that Chillicothe will be included in its scheme of central power stations for Ohio utilities properties. It is understood that the company has plans for enlarging and extending the generating power plants at Chillicothe and broadening the market for this current. Negotiations are said to have been opened for the central station at Circleville and Washington C. H., which, if consummated, would place these two cities in the power zone of the Chillicothe plant.